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JOURNAL

VOLUME 13, NUMBER 3 • MARCH, 1957

Plastics in Nuclear Research

. . . help science
invade
the atom

. . . page 26

UNIVERSITY OF MICHIGAN
MAR 15 1957
EAST ENGINEERING LIBRARY

New colorful styles... attractive designs for aerosols

with Du Pont ZYTEL® nylon resin

Now, by using ZYTEL nylon resin, plastic molders can produce a wide variety of sales-appealing shapes and color combinations for the packaging engineer designing aerosols. Two new developments are responsible for the expansion of design opportunities.

First of these developments is a new technique for welding two injection-molded sections of ZYTEL, forming a single aerosol unit. This new technique has been found to be an efficient and sure way of joining plastic sections, and enables the designer to create an aerosol package in various attractive colors.

A new grade of ZYTEL, type 42, is the second development. ZYTEL nylon resin, type 42, has the optimum viscosity for extrusion and blow molding. This fabrication method allows great freedom of design, and many unusual shapes are now practical.

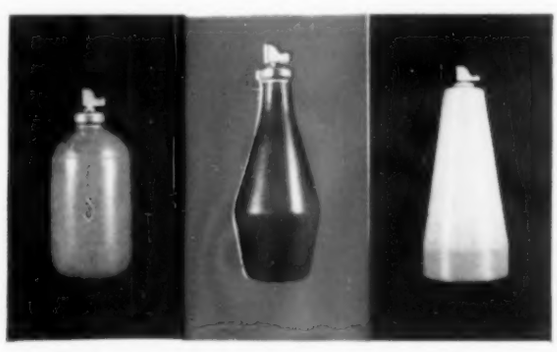
A container molded of ZYTEL is impermeable to the propellents used in aerosols. The chemicals in such products as antiperspirants, colognes and hair lacquers will not attack ZYTEL.

ZYTEL may very well supply the answer to a current design problem of your own. Make it a point to write today for more information to E. I. du Pont de Nemours & Co. (Inc.), Room 453, Wilmington 98, Delaware.

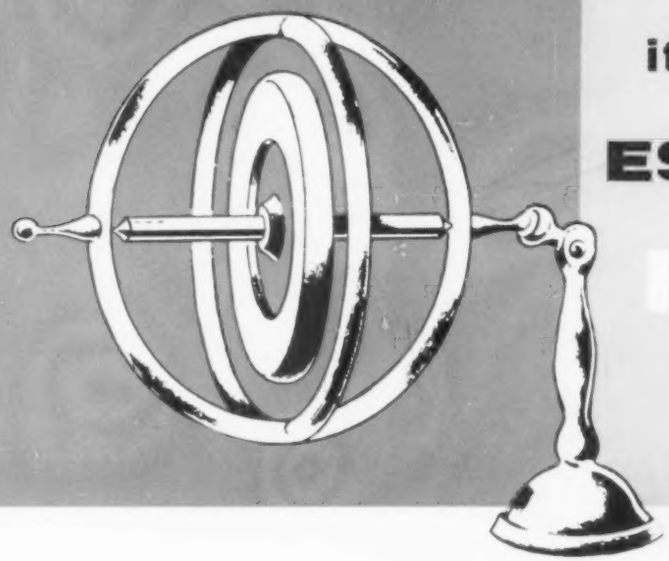
DU PONT

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

ZYTEL *nylon resin makes possible new, colorful designs for aerosol containers. A new grade* ZYTEL, *type 42, and a recently developed fabricating technique are responsible for the entrance of* ZYTEL *into the aerosol field.*



FOR HEAT STABILITY*.....



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* **HEAT STABILITY** in Escambia PVC is improved to give you better control over color drift and other processing problems.

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ESCAMBIA PVC 1225– Intermediate molecular weight, particularly adapted for supported and unsupported sheeting.

ESCAMBIA PVC 1200–lowest molecular weight in this series, designed for flexible and rigid sheeting.

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Vol. II, No. 2

POLYETHYLENE PROCESSING TIPS

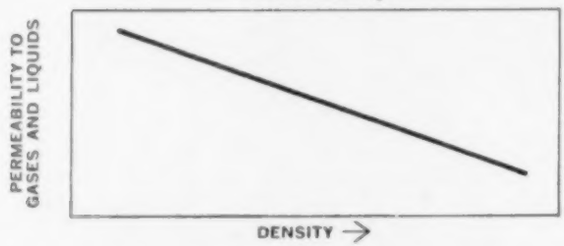
HOW RESIN DENSITY AFFECTS POLYETHYLENE PROPERTIES

The *density* of a polyethylene is one of three basic characteristics which determine the properties of a processed part. The other two basic characteristics are *molecular weight* and *molecular weight distribution*. Relationships among the three were discussed in Tips, Vol. 2, No. 1 (reprints are available).

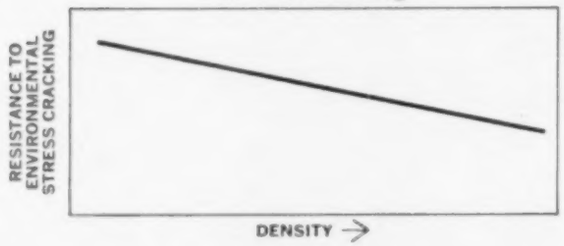
Polyethylene density can range from 0.910 to 0.965. The graphs below indicate what happens to certain properties as density of the resin increases, assuming the other two basic characteristics do not change.

It must be remembered, though, that these graphs do not give the entire story. Molecular weight and molecular weight distribution are often different in resins of different densities, so the effects of all three must be taken into consideration if the end properties are to be predicted. The effects of these other characteristics on end properties will be discussed in future issues of "U.S.I. Polyethylene Processing Tips".

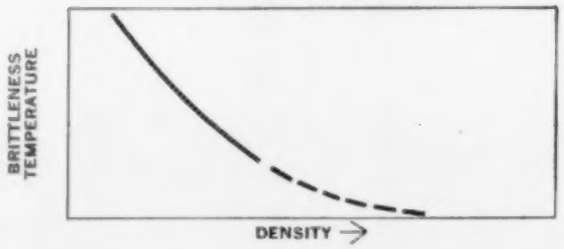
Permeability



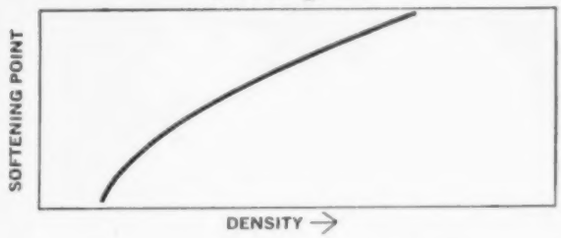
Resistance to Environmental Stress Cracking



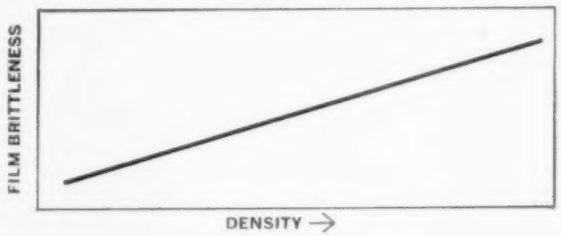
Brittleness Temperature



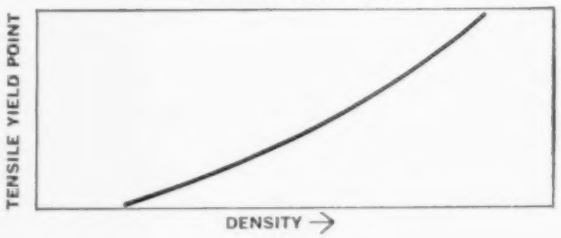
Softening Point



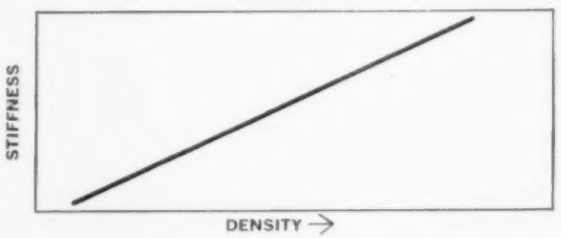
Film Brittleness



Tensile Yield Point



Stiffness



U.S.I. PETROTHENE® Polyethylene resins are now available in densities up to 0.925 and will soon be available over a wider density range. Molecular weight and molecular weight distribution can also be varied at will.

U.S.I. technical service engineers will be glad to work with you to determine what resin characteristics can give you the properties most suitable for the polyethylene product that you are making – or plan to make.

U.S.I. INDUSTRIAL CHEMICALS CO.
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SPE JOURNAL

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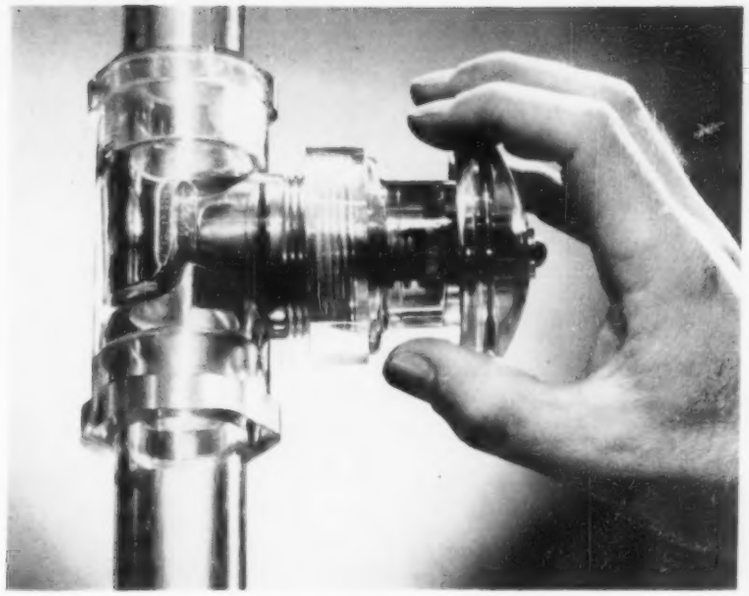

A new globe-type valve has been introduced which can never rust and resists the corrosive action of many "problem" chemicals. Made of durable butyrate plastic, the valve's interior surfaces are extremely smooth, permitting an unimpeded flow through the unit. When it is closed, a positive plastic-to-plastic seal is formed. There are no washers to deteriorate and cause downtime. And since the valve is transparent, flow can be observed readily.

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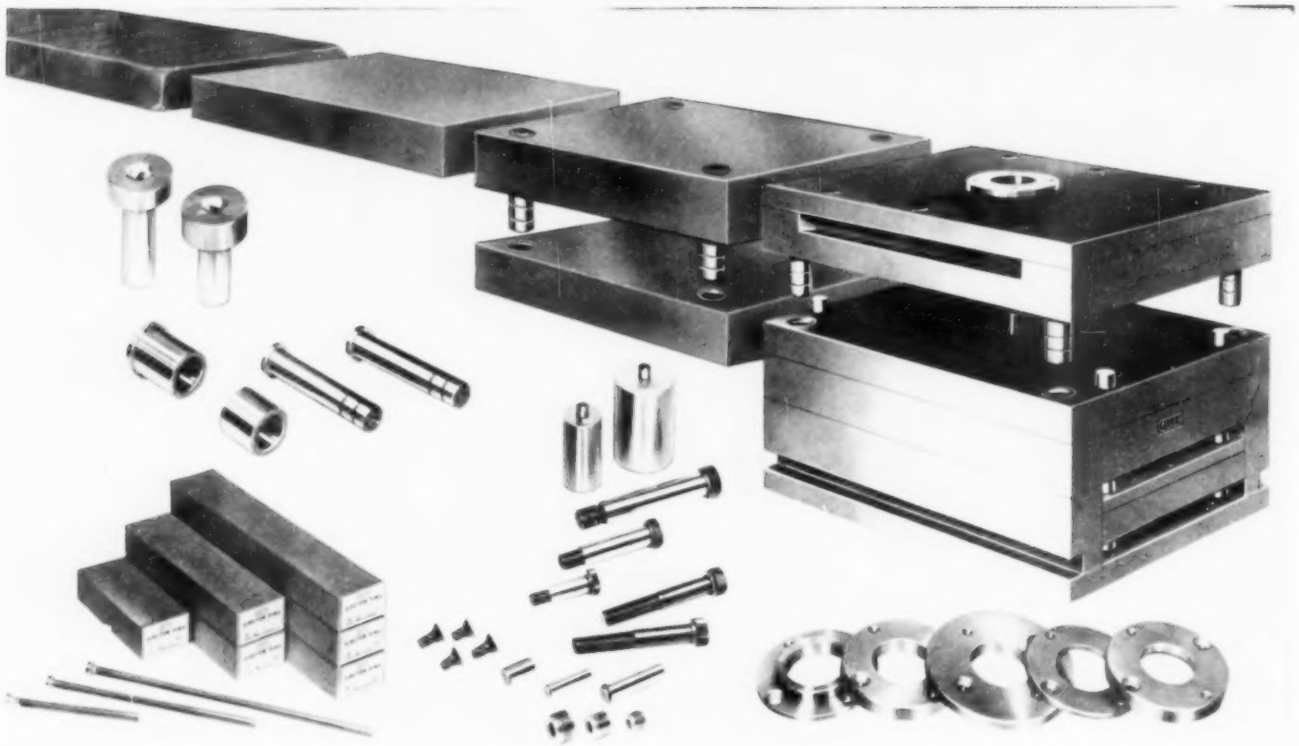

PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

When D-M-E originated Standard Mold Bases and their component parts in 1942, it provided the answer to the rapidly growing demand for high quality molds that would maintain and promote the economic advantages of plastic parts.

Through large volume purchases of quality steel in standard sizes and specialized production facilities, D-M-E was able to produce and supply high quality Standard Mold Bases to mold makers and molders at such great savings in cost and time that the benefits of Standardization were quickly realized by the Industry.

Today D-M-E produces twenty-eight different sizes of Standard Mold Bases, from 9" x 8" to 23¾" x 35½", in either D-M-E No. 1 or No. 2 Steel, with a wide range of cavity plate thicknesses to satisfy the diversified demands required. In addition, over 2,000 finished component parts of the same high quality are available to provide additional savings in service as well as in the product.

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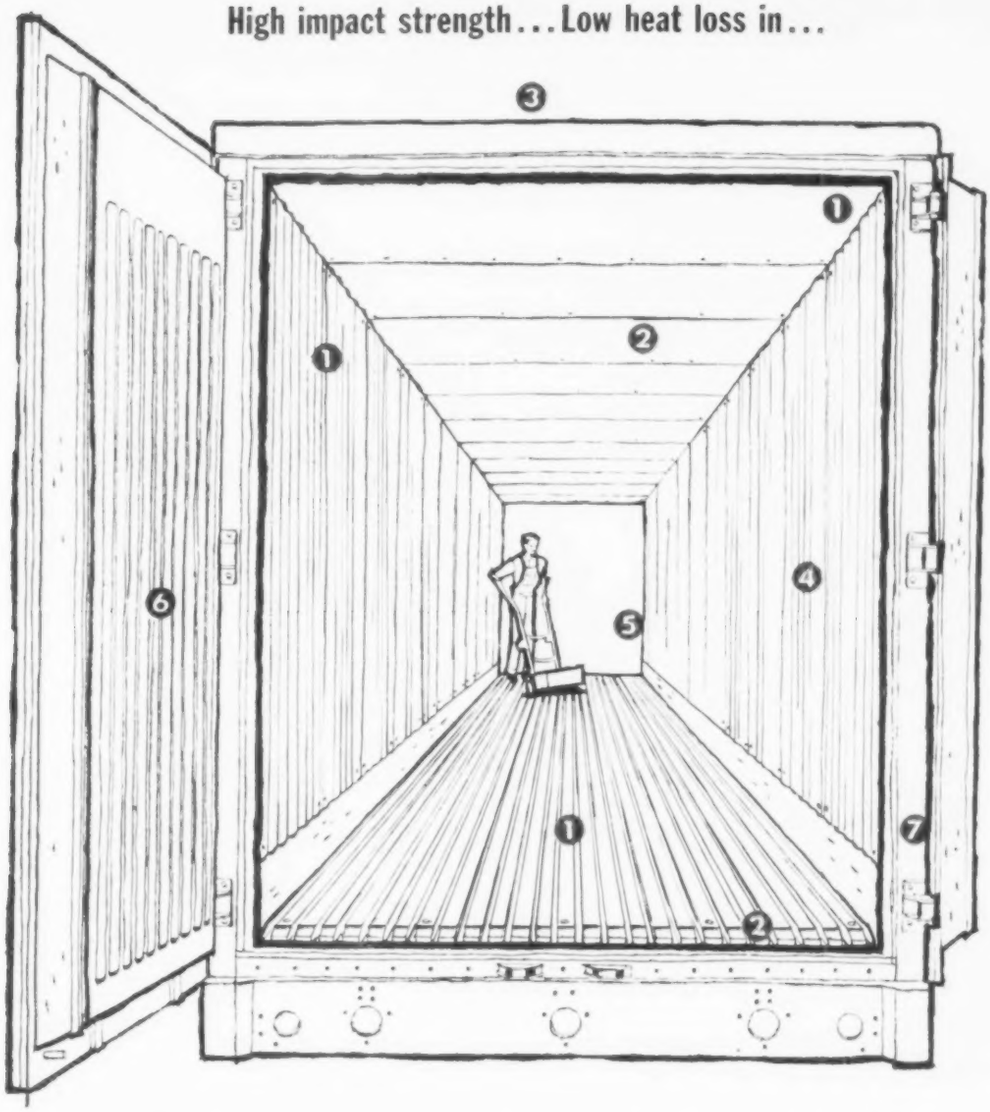
High impact strength... Low heat loss in...



1. Posts, roof bows and floor channels made of Strick Lamicor® from glass-reinforced RCI POLYLITE polyester resin. Not a single case of fatigue failure in two years of over-the-road testing.

2. Ceiling lining and shear sheets made by Strick from POLYLITE and glass cloth or mat laminates up to 50" x 100".

3. Translucent skylights of very high impact strength Lamicor made of polyester resin with 45% glass reinforcement.

4. Corrugated side linings (with or without slotted edges) made of fibrous glass-reinforced POLYLITE. Strick offers these panels with either vertical or diagonal corrugation.

5. Lining panels made of Strick Lamiclad® from POLYLITE and plywood laminates have excellent impact and cleaning properties.

6. Strick all-plastic trailer doors 4" and 6" thick made of reinforced POLYLITE resin in sizes up to 44" x 106".

7. Door framing made by Strick of reinforced POLYLITE in shapes up to 110" long.

Trailer components made by STRICK PLASTICS from RCI POLYLITE RESINS

• For two important reasons the Strick Plastics Division of Fruehauf Trailer Company, Perkasie, Pa., makes a wide range of trailer components from RCI POLYLITE polyester resin.

First, the strength-weight ratio of these reinforced polyester parts is superior to both aluminum and steel.

Second, the K-factor of heat loss through these plastic components is a small fraction of that for aluminum or steel. This advantage is especially important in reefer construction.

In "reefers", plastic components also eliminate the danger of cargo spoilage from wood stringers that have become rotted, pest-infested or odor-contaminated. Plastic parts made with POLYLITE resin do not rot or attract pests. They are durable and easily cleaned.

At RCI we have three lightweight, plastic trailers that were made for us by Strick. Entire exterior, interior and all structural members of these insulated vans are made of reinforced RCI POLYLITE polyester resin.

In small parts or something as big as a whole trailer POLYLITE construction can offer *you* advantages, too. Do you want lightweight strength? Durability? Easy maintenance? Bright built-in colors or translucence? Write to RCI about POLYLITE for your products. Ask for *Booklet A*. Reichhold Chemicals, Inc., RCI Building, White Plains, N. Y.

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VISIT THE RCI EXHIBIT BOOTHS 338-340

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MARCH 18-21, 1957

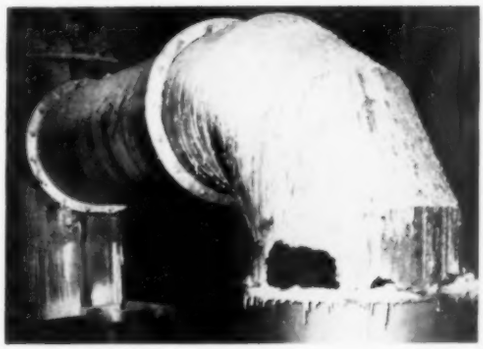
SHRINE EXPOSITION HALL, LOS ANGELES

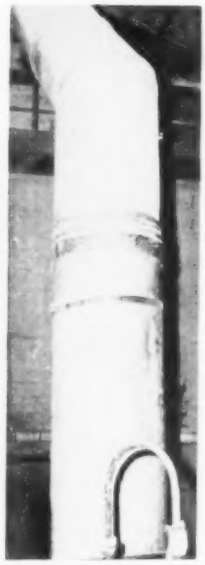
CYANAMID

PLASTICS NEWSFRONT

THREE YEARS IN CORROSIVE SERVICE WITHOUT MAINTENANCE

That's the record established by reinforced LAMINAC® polyester resin in venting service on alum digesters at Cyanamid's Warners plant. The carbon steel breech (left) in an alum evaporator required frequent maintenance, failed after less than three year's service. Glass-reinforced LAMINAC stacks (right) in even more severe alum digester service, have needed no maintenance in more than three years. The LAMINAC units cost less in the long run, and were easier to erect and assemble, using either telescope joints wrapped and polyester-welded on the site, or flange-type joints.





ATTRACTIVE, AIRTIGHT CASE FOR STICK COLOGNE

Six new scents of Avon Stick Cologne are packaged in smartly styled, practical cases molded of BEETLE® urea molding compound. Cases have a white base with contrasting closures in a different color for each scent. Airtight, the BEETLE case stops evaporation of the cologne. Yet the closure opens easily, and with a twist of the wrist the stick pops up for use. The case resists alcohol, essential oils and chemicals as well as staining from perspiration and grime, which wipe off easily.

FUNCTIONAL HANDLES GRACE CARAFES

Any dining or buffet table would be graced by this attractive carafe with its stylish, beige-colored handle molded of CYMEL* melamine molding compound. Elegance and function are combined in the handle, balanced for easy, comfortable pouring. Harmonizing with the carafe's gold decoration, the molded-in color won't chip or wear off. In keeping with its function, CYMEL is exceptionally strong, resistant to heat and flame, and stays cool even when the carafe, made by Club Aluminum Products Company, is full of hot coffee.

*Trademark

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MATERIALS FOR TOMORROW

FEWER REJECTS—HIGHER RESIDUAL STRENGTH PROVED

...in production run of Vacuum Formed Door Liners with

MONSANTO LUSTREX® Styrene Plastic

Here is a doubly critical operation of sheet extrusion and final vacuum forming of impact-proof refrigerator door liners. Quality requirements for these finished liners are high! The raw material must extrude sheets that are easily vacuum formed into complex die shapes. At the same time, cycles must be rapid. The refrigeration end use requirement demands an odor-free styrene. But most important, high vacuum forming temperatures cannot affect basic strength of the finished door liners! These are rigid specs for any material.

In a recent run of 7,350 liners, Lustrex Hi-Test 88B met and exceeded these requirements. Paul Schmidt, Chief Thermoplastic Engineer of the Panelyte Division of St. Regis Paper Co., reports, "Working with extremely complex dies, sheets extruded from Lustrex Hi-Test 88B give us excellent resilience and constant flow regardless of high heat cycles ranging from 350°-500°F. In addition, resultant strength characteristics are maintained at a steady peak level." The finished vacuum formed Lustrex liners also pass the "slam door test"—an over-loaded door slammed shut thousands of times to simulate years of actual use. Performance like this cuts rejects at the assembly level to a fine minimum . . . proof again of Lustrex performance and economy.

Investigate the moldability, strength and economies of Lustrex Hi-Test 88B for your next difficult requirement. Write for complete technical data to Monsanto Chemical Company, Plastics Division, Room 1871, Springfield, Mass.

LUSTREX HI-TEST 88-B

MONSANTO

THE MARK OF QUALITY

BARBER COLMAN

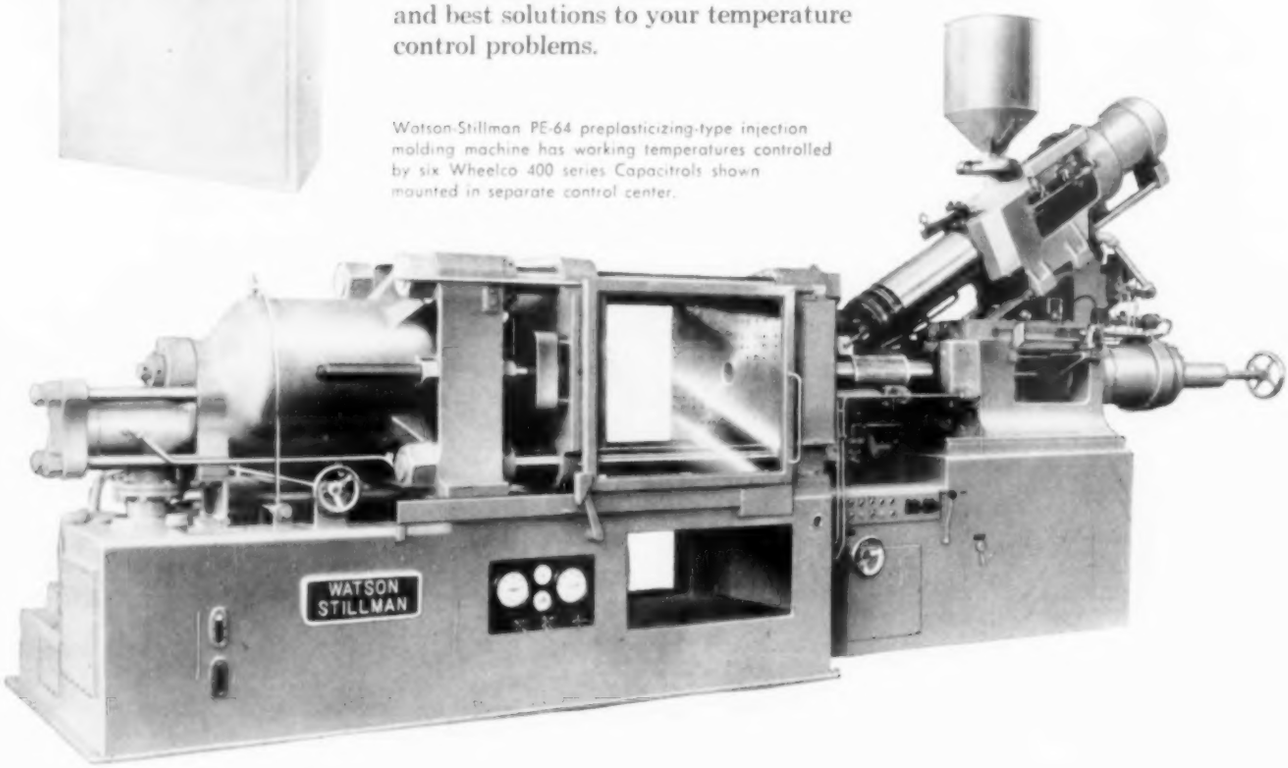
Wheelco Instruments

Precise temperature control boosts capacity of molding machine

Preplasticizing unit on these Watson-Stillman molding machines increases capacity up to 90 ounces. Unit heats material to a plasticized state and delivers it to the injection cylinder ready for molding. Outstanding user benefits include: shorter molding cycles, improved shot thickness control, lower injection pressures, and greater uniformity in material and coloring.

Latest type heating cylinder of the PE-64 machine depends on six Wheelco 400 Series Capacitrols for precise, continuous, multi-zone temperature control of the internally heated torpedo. Extreme accuracy and dependability of Wheelco Instruments makes them ideal for across-the-board installations in the plastics industry.

Survey the plastics industry — either quickly or thoroughly — and be convinced that Wheelco leads in instruments without any shadow of a doubt. Then, call your nearby Wheelco field engineer for the quickest and best solutions to your temperature control problems.



Watson-Stillman PE-64 preplasticizing-type injection molding machine has working temperatures controlled by six Wheelco 400 series Capacitrols shown mounted in separate control center.

BARBER-COLMAN COMPANY

Dept. O, 1575 Rock Street, Rockford, Illinois, U.S.A.

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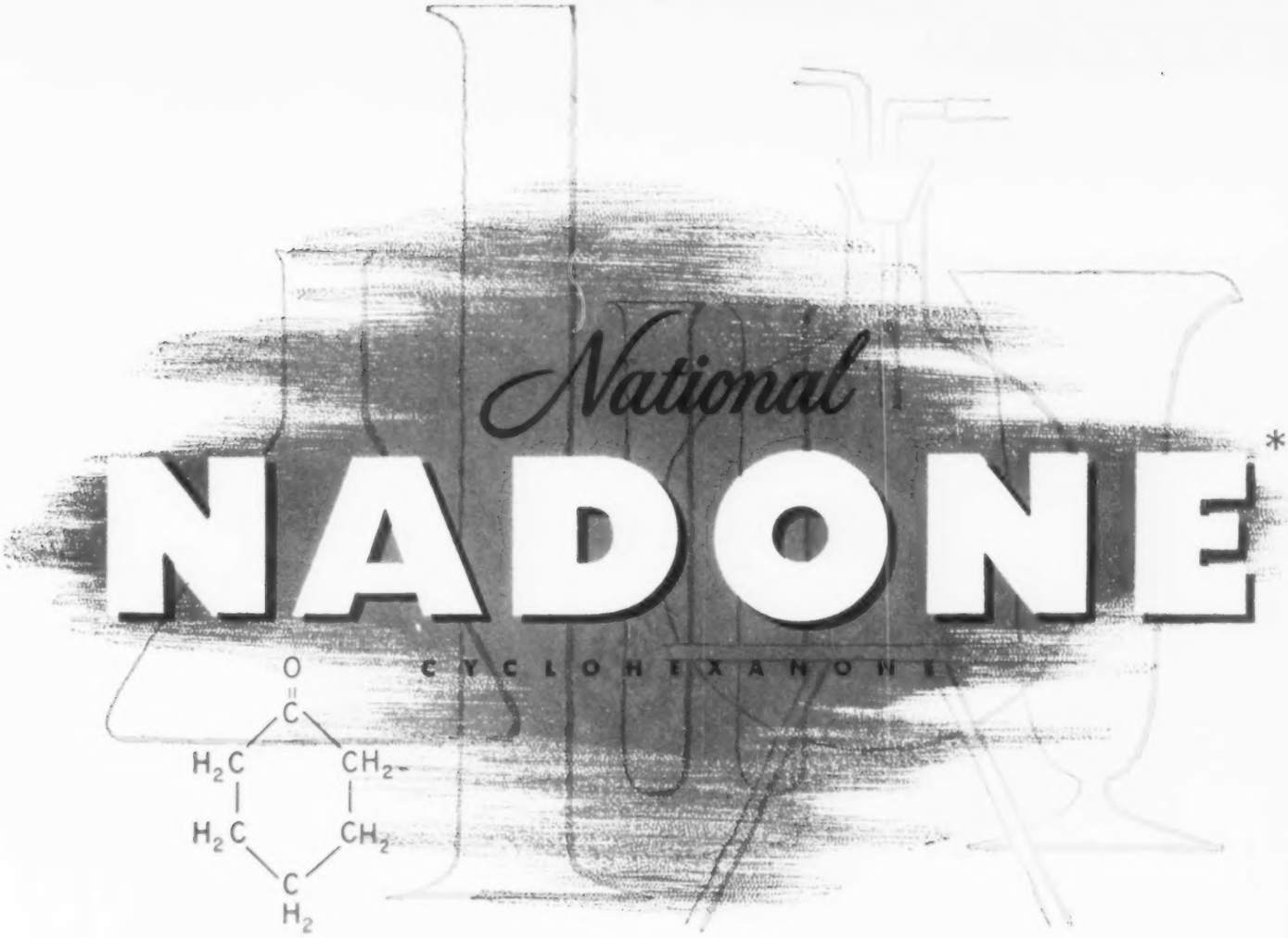

new higher-quality cyclohexanone from a new basic source!

NADONE is the brand name for National Cyclohexanone . . . highest quality volume-production cyclohexanone offered. Minimum purity 99.0%!

National Aniline now gives the resin, plastics, coatings and chemical industries a dependable new source of supply. Production is fully integrated within Allied Chemical and volume is freely available in tank cars or drums from our well-situated plant at Hopewell, Virginia.

Working samples of NADONE are available to show prospective users its exceptional quality.

Bulletin I-19 gives properties, reactions, suggested uses and bibliography. Use the convenient coupon.

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M-6

IS BLACK A COLOR?

Strictly speaking no, yet ADP frequently is called upon to match a certain shade of black. Can we do it? Of course . . . black or any other color . . . because color dispersions are our business.

Matching shade is only the beginning. Because ADP dispersions are colloidal in nature, they remain uniform throughout the compound . . . and a little goes much further than ordinary mixtures. So your end product is better and costs less, too. And when you re-order, you will get the same shade, same uniformity, same economy.

Instead of wrestling with costly dispersion problems yourself or putting up with ordinary mixtures produced by other methods, call in an ADP specialist. He will work closely with you on an individual basis. Your business is plastics . . . ours is controlled dispersions . . . any color, and black.

***controlled colors by adp**

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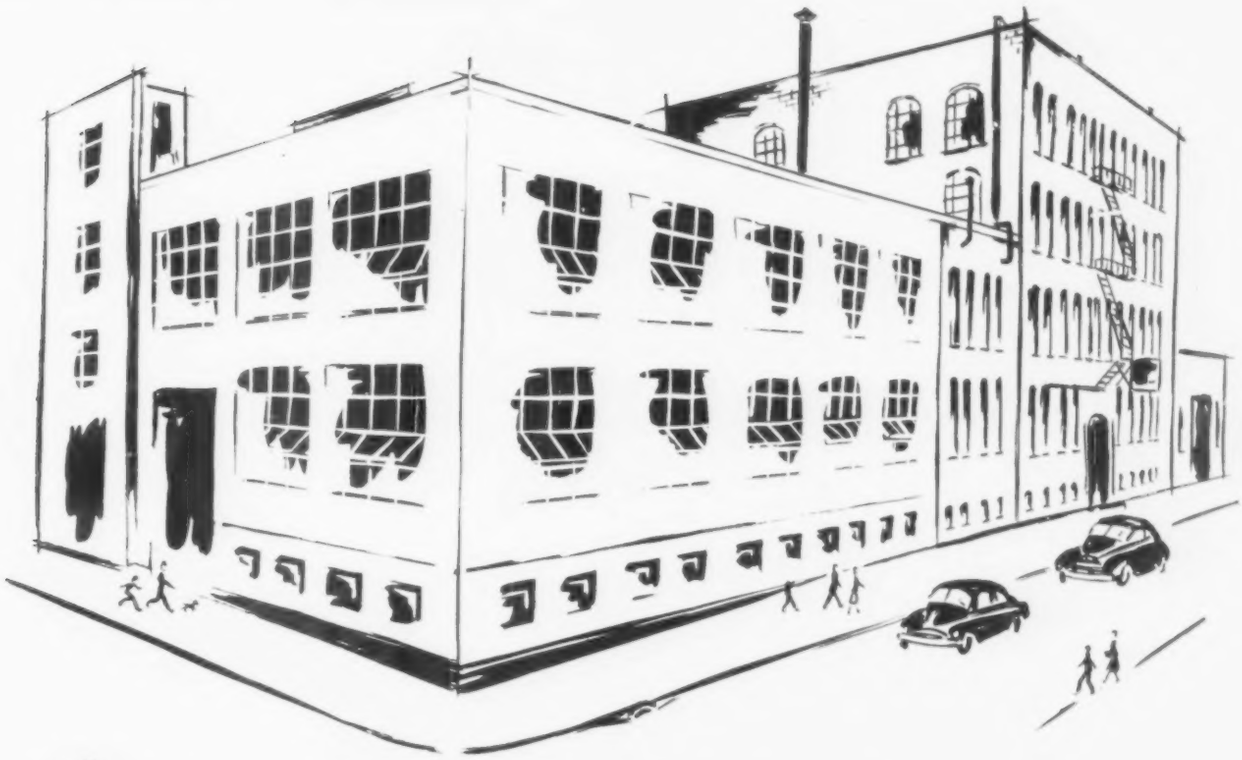
*Because ADP dispersions are colloidal in nature, with pigment particles of microscopic size.



Additional Plant Facilities...

TURN OUT BIGGER MOLDS ... AND DO IT FASTER

to serve the customers of Newark Die

The new machine tool facilities of Newark Die Company are housed in a modern building that is designed throughout for the efficient handling of molds in *really* big sizes. Floors are constructed to withstand heavy loads. Overhead cranes and other up-to-the-minute materials handling equipment keep big molds moving smoothly through the plant.

This plant expansion has greatly increased our ability to provide prompter, more economical service on molds, hobs and hobbed cavities — *with even greater accuracies than ever before.*

Write for articles on Solving Big Mold Problems and New Revolutionary Type Injection Molding Machines.

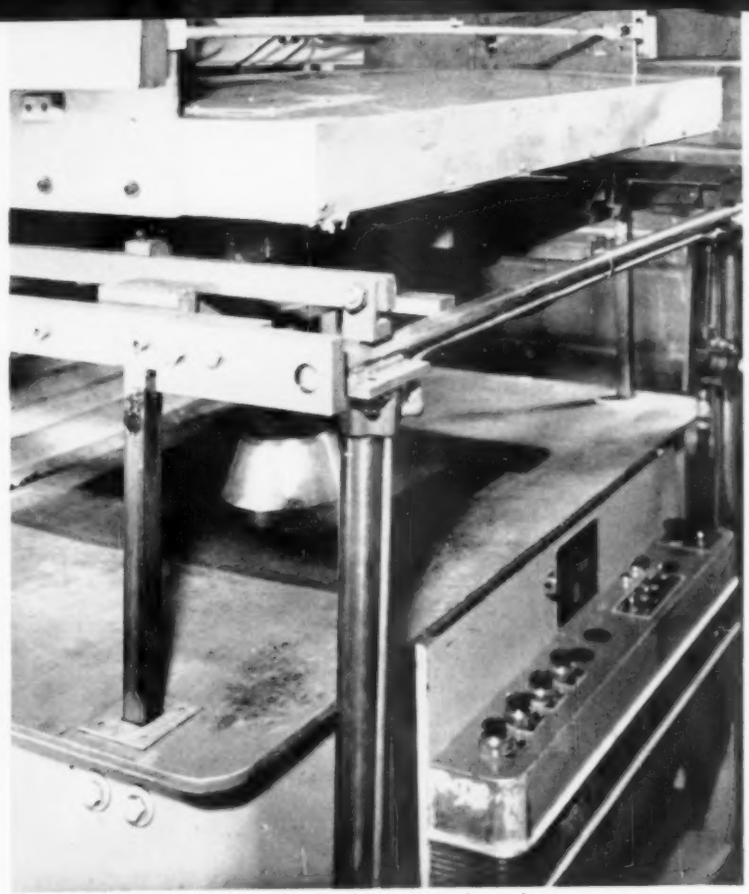
NEWARK DIE COMPANY

22 SCOTT STREET, NEWARK 2, N. J.

Phone: MArket 2-3305

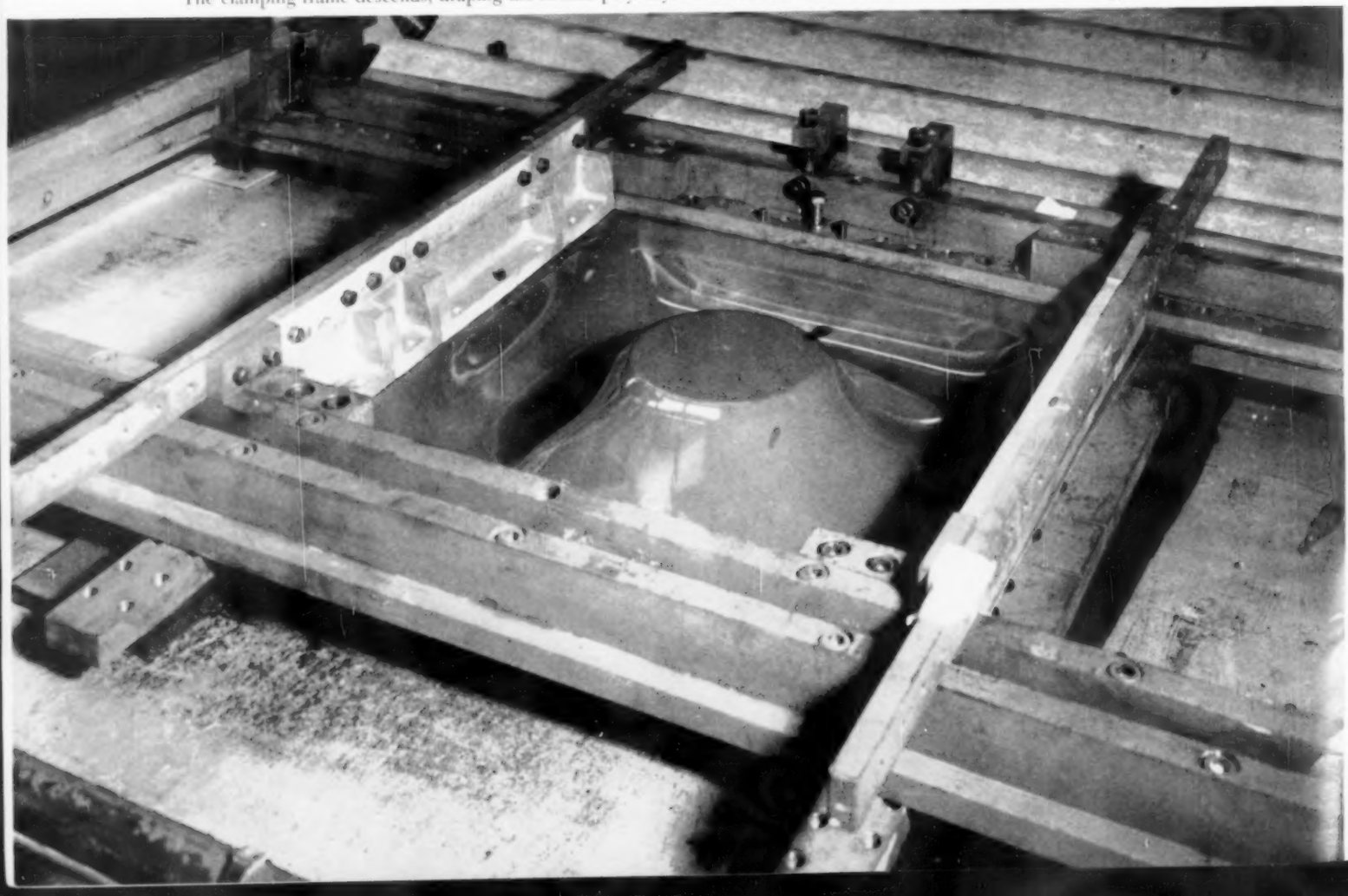
NDC TRADE MARK

The high-gloss quality of the polyethylene sheet is evident here as it is placed into the clamping frame of the vacuum-forming machine.



The heater is drawn forward over the polyethylene sheet with the bowl mold in position. The diameter of this mold is about eight inches.

The clamping frame descends, draping the heated polyethylene sheet over the bowl mold before the vacuum is applied.



Polyethylene for sheet extrusion and vacuum forming

Facts about BAKELITE Brand Polyethylene DFD-4030

The first polyethylene material specifically compounded for sheet extrusion and vacuum or thermo-forming is being produced by Bakelite Company under the designation DFD-4030. This development is the result of an investigation of this promising new field by Bakelite Company Research & Development Laboratories.

It can be fabricated most rapidly by modifying equipment now being used for continuous in-line extrusion and vacuum forming of impact styrene.

While DFD-4030 is still new, laboratory and field experience has already shown that its production and performance properties will fit a wide range of applications, of which housewares offer a prime example. Among the advantages are:

High molecular weight—as evidenced by low melt index. Averaging approximately 2.0, this gives improved resistance to stress cracking.

Superior gloss—even during deep-draw formings, DFD-4030 maintains a superior gloss and finish.

Unlimited colorability—a complete dispersion of colorants and the elimination of streaking can be achieved. Since color is an integral part of the product, it will not scratch, chip, or wash off.

Rapid, trouble-free processing—with freedom from skinning and chatter marks.

Other important properties are covered in the table opposite.

A continuing development program is being conducted by Bakelite Company to study new equipment and techniques that can be used with BAKELITE Polyethylene Compound DFD-4030. As a result of studies carried out at the Extrusion Materials Laboratory, the technical staff is prepared to assist fabricators in developing or altering equipment to handle this material. For technical information or assistance, write Dept. WJ-171

TYPICAL PROPERTIES OF POLYETHYLENE COMPOUND DFD-4030

Values obtained from extruded sheet

Melt Index g./10 min at 190 deg. C. (D1238-52T)	1.7 –2.4
Specific Gravity (D792-50 Method A)	0.92
Durometer Hardness "D" Scale (D676-49T)	40 at 75 deg. F. 28 at 140 deg. F.
Tensile Strength (D412-51T), psi	1800
Per Cent Elongation (D412-51T)	550
Stiffness Modulus (Torsion) (D1043-51) at 23 deg. C.	22,000
Izod Impact Strength (D256-54T) ft-lb/in. of notch	16
Heat Distortion Temperature (D648-45T) (at 264 psi) deg. F.	120
Brittle Temperature (D746-55T)	
80 per cent non-failure, deg. C.	–80
50 per cent non-failure, deg. C.	–100
Coefficient of Linear Expansion (D696-44) at 75 deg. F. (in./in.) deg. F.	3×10^{-4}
Coefficient of Thermal Conductivity cal./sq. cm./sec./cm./deg. C.	8×10^{-4}
Specific Heat, Cal./gr./deg. C.	0.53
Heat of Combustion, cal./g.	11,000
Coloring Properties	Unlimited
Water Absorption (D570-54T) (per cent gain in weight in 24 hours) 75 deg. F.	0.01 Maximum
Volatility Loss, 72 hours at 82 deg. C.	0.0 Per Cent
Volume Resistivity (D257-54T) at 25 deg. C.	1×10^{7} ohm–cm.
Dielectric Strength (D149-55T) at 25 deg. C.	1000-1100 volts/mil
Dissipation Factor (D150-54T) at 25 deg. C.	1 MC 30×10^{-3} 50 MC 30×10^{-3}
Dielectric Constant (D150-54T) at 25 deg. C.	1 MC 2.3 50 MC 2.29

BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.

MARCH
1957

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

PRACTICAL ANSWER TO STATIC DUST COLLECTION

DOW RESEARCH SHOWS HOW TO SPECIFY PROPER TREATMENT TO ASSURE DUST-FREE POLYSTYRENE SURFACES

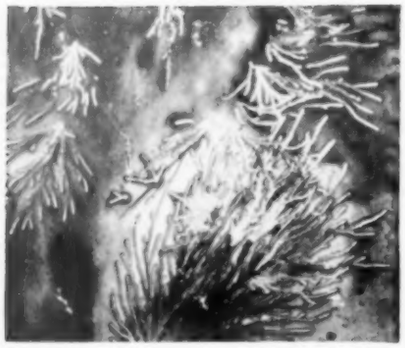


FIGURE 1

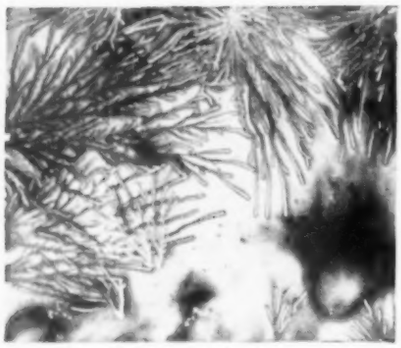


FIGURE 2

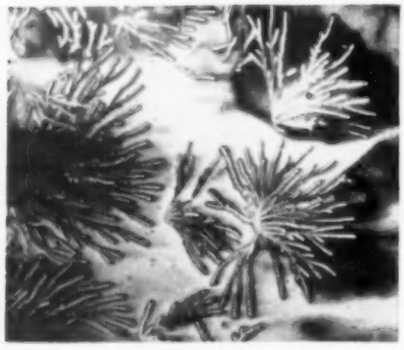


FIGURE 3—*Figures 1, 2 and 3 show typical static dust patterns on nontreated plastic surfaces as reproduced by Dow process using fluorescent pigments and "black light".*

FIGURE 4—*Here the same "black light" technique shows the absence of static charge on plastic surfaces destaticized by new method.*

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON® 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

Static electricity which attracts and holds dust has long been acknowledged a problem in the manufacture and use of plastic products.

To overcome this behavior, Dow Plastics Technical Service developed new techniques for obtaining, observing and recording dust deposits. With these tools, Dow research explored hygroscopic chemicals that render the surface hydrophyllic or, in other words, that destaticize it.

A method was developed and conclusively tested to provide freedom from static for long periods of time. This method includes dipping, spraying or otherwise coating moldings with a dilute detergent solution that reduces electrostatic charges to levels that prevent dust pickup.

FREE BULLETIN

A list of suitable compounds together with further information on this subject are contained in the bulletin, "Static Dust Collection of Plastics". Address: THE DOW CHEMICAL COMPANY, Midland, Michigan—Plastics Sales Department PL1540J.

YOU CAN DEPEND ON DOW

New Gating for Acrylics . . .

J. F. Moore
Rohm & Haas Co.

. . . . "tab gating" is the use of a tab or vestibule in place of the usual gate . . . molten plastic enters the tab from the side through a restricted entrance. Advantages can include lower mold cost and better physical properties in the molded part . . . .

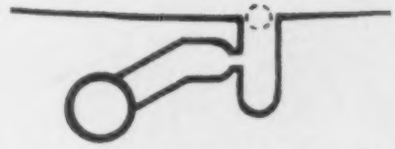


Figure 1. In this "tab-gate," plastic flows left to right

THE CONSTANT SEARCH for "a better way" to produce injection molded parts of good quality and finish at the lowest price is a never-ending project for designers, molders, material suppliers and end users. Here are some observations made during several years of seeking improvement in the injection molding of acrylic parts . . . . .

One of the basic requirements in the molding of acrylics is to deliver material sufficiently hot and fluid to the mold cavity. Acrylics are relatively viscous polymers at molding temperatures, requiring careful control of the gating and runner system in order to obtain the optimum luster and physical properties. It is very desirable to minimize the effects of the heat loss through the sprue and runner system. Suggestions are made in this paper on methods of counteracting the heat loss in the runner system on both conversion molds and new mold designs.

Trial and Error

The present practice of gating has been developed by years of "cut and try". Several excellent books have been written by qualified authors on the subjects of flow theory, mold construction and physical properties of molding materials. Few if any, however, of these articles give any useful information on methods of gating the part. This problem is usually left to the individual molder. Different molders using the same cavities have been able to gate them in different ways and produce acceptable parts.

It is well known that gating directly into the cavity area will permit filling the cavity without welds, bubbles or surface splash, if the gate is large enough and runners and sprue are adequate. If the gate is too small, the cylinder temperature must be raised and the maximum plunger pressure used to get a satisfactory flow pattern in the mold. If the projected area of the parts is increased, the gates must be increased in area and the parts then become more difficult to degate with a satisfactory finished appearance.

With improved physical properties uppermost in mind, it was felt that a different method of gating acrylics could be developed that would give good finish, minimum of welds and tails over and around characters and legend, and good dimensional stability with respect to mold shrinkage and warp. The theory behind this thinking was that a higher material temperature and more uniform cavity pressure were necessary. The end results of this study and practice was called "tab gating".

Tab Gating

Figure 1 shows a typical single cavity tab gated mold. The normal methods of gating this part would be either to use a fan type gate an inch or more wide or a three-plate mold gated across the top of the third plate, through a sprue bushing or well into the side of the molded part. The latter involves a higher mold cost, plus the loss of material in the long runner and sprue bushing. Moreover, conventional gates often cause high molding stresses which are difficult to remove by annealing.

With tab gating a small gate is cut between the ball end of the full round runner and the tab, which is directly connected to the cavity wall where the gate is normally cut. The small gate builds up temperature by restriction, and causes the hot plastic material to impinge against the blank wall of the tab. The plastic front is smoothed out and fills the cavity area with an even flat flow of plastified material. This eliminates the jetting or racing caused by gating directly into the cavity by usual means.

The tab gate (for a 17 inch television implosion shield) shown in Figure 1 uses an actual gate 0.120" thick by 0.150" wide with a 0.060" land. The runners are 0.375" full round. The tab is 0.125" x 0.500" x 1.125". It was found that lower than normal plunger pressures could be used, since the restricted gate and flattening effect of the tab filled the mold easily. Only one knock-out pin is used to eject the part from the cavity. It is not necessary to "pack" the cavity in order to get filled parts and therefore it is not necessary to use many knock-out pins to eject it.

It might be pointed out that some molded parts of this type tend to stick in the female half of the mold,

Tab Gates for Multiple Cavities

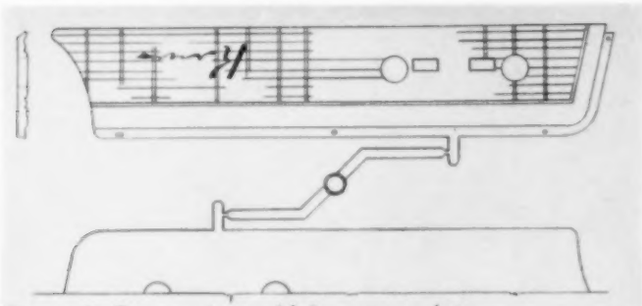


Figure 2. Two cavity mold for name plate.

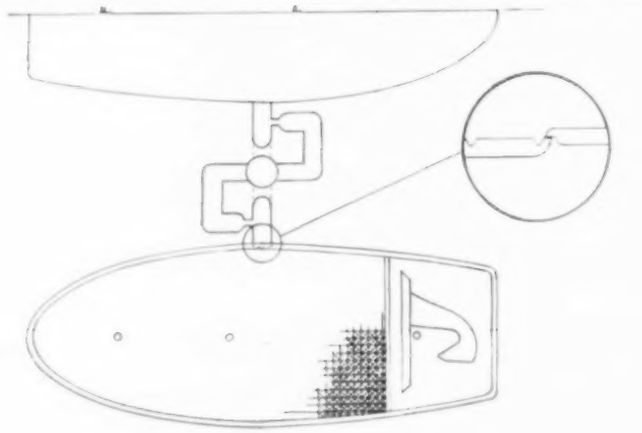


Figure 3. This two cavity name plate mold was converted from ordinary gating to tab gating.

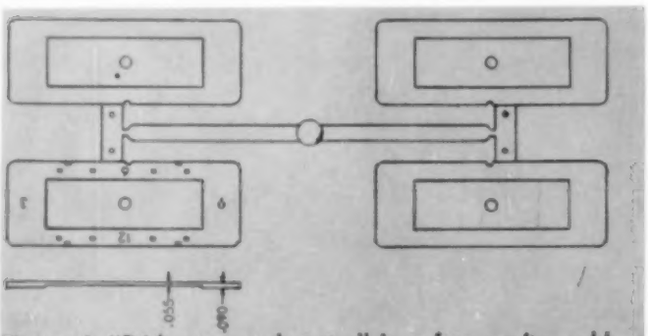


Figure 4. "Bridge-type tab gates" in a four cavity mold.

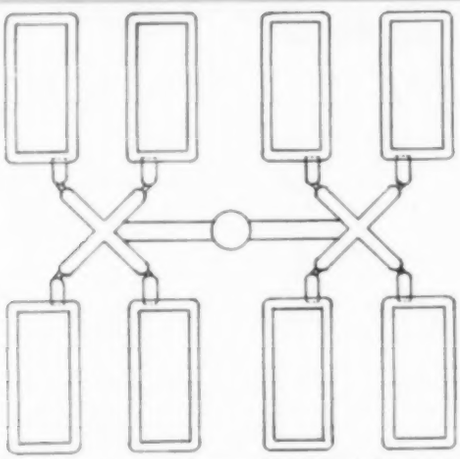


Figure 5. Tab gates can be angled for eight cavity mold.

because of part design and inability to admit air behind the part. It is interesting to note that with tab gated parts of this nature, even though the parts may stick slightly and the gate fractures as the platens open, the molded part remains intact and can usually be saved for production. Another interesting feature is that runners and sprue bushings may be fed back into the machine by merely breaking the runners from the tab, without contaminating the clean material in the hopper. No contact with saws or cutters is required and the runners are kept clean. The operator should, of course, use gloves.

Tab Gates for Multiple Cavities

Figure 2 shows a two-cavity tab gate layout. This was the original gating layout for the study, and the mold ran very well. Trapezoidal 0.343″ runners were used. The gate is 0.125″ x 0.187″ x 0.187″ land. The tab is 1.0″ long x 0.343″ wide x 0.187″ deep.

Figure 3 shows a two-cavity tab gate layout that was converted from conventional gating to overcome high crazing sensitivity of the part when painted, splash on the surface and short shots. Note that the part is gated under the edge of the very thin wall section, so that the original gating area was restricted to about 0.060″ x 0.375″. To follow the pattern established in Figure 2 it would have been necessary to cut tabs into the sidewalls of the part, recut the runners, weld up the old runners and gates and then polish the sidewall gate area after molding. Instead, the molder made two right angle turns with the runner and gated directly into the center of what remained of the old full round runner. This different approach to tab gating worked very well, producing better parts with less craze tendency, at lower molding pressures and cylinder temperatures. Specifically, the tab size is .500″ long x 0.375″ diameter. The gate into the tab is 0.050″ x 0.100″ with a 0.080″ land. The gate from the tab to the part remains as above.

With some experience in gating single and two-cavity molds, it became desirable to devise methods of gating four-cavity molds. A "bridge" type tab was worked out by cutting a single tab between two cavities. The gate is located in the center of the bridge tab and in a direct line, if possible, from the sprue bushing. Figure 4 shows a 4-cavity clock dial mold gated in this manner. The tabs running between the cavities are 0.375″ wide and 0.060″ deep. The gates feeding these tabs are 0.060″ x 0.060″ with a 0.070″ land. The runners may be parted from the tabs and the tabs easily removed from the molded part by the use of a hot knife or slitting saw, leaving a finished, chip-free surface.

More Than Four Cavities

In multiple-cavity molds (over four cavities) it is not always possible to gate at right angles to the tab. It is feasible to cut the tab extending out from the cavity as before, but the gate in this instance is cut into the end of the tab between the straight full round runner and the tab. Figure 5 shows a typical mold layout for this type of tab gate. It is not as desirable as the right angle gate but satisfactory. In this example the gate is 0.080″ x 0.080″ with a 0.070″ land. The tab is 0.500″ long x 0.281″ wide x 0.150″ deep.

In a further study of multiple-cavity molds where the secondary runner layout formed an "X" design, it was found that the four inside cavities showed better fill properties and less variation than the four outside

cavities. It appeared that a better, more uniform fill pattern was necessary to fill all cavities smoothly and at exactly the same time. In accomplishing this, it was necessary to keep in mind the desirability of equalizing the runner distance from each cavity to the sprue. Also, it is convenient and economical to core the mold for heating and cooling in a straight line. And finally, experience had indicated that moldability and finish are improved by gating at right angles to the tab rather than into the end or at any other angle.

The result was a uniform layout which, for want of a better name, is called an "H" runner design, since the secondary runners suggest that shape. This design is easy for the mold maker to mill, since all milling cuts are at 90° to each other. Thus the cavities can be lined up in a uniform, geometric pattern. Figure 6 shows a typical "H" type runner layout that molded very well. It combines good molding with ease of degating and handling as the molded shot is ejected from the machine.

Runner Blocks

Since not all types of molds lend themselves to tab gating by the methods described, yet there is a need for methods of obtaining improved physical properties and better moldability in molds presently gated by conventional methods. Molds of this type include multiple-cavity horn button molds, reflector molds, irregular hemispheres, bubbles, marker lights and cones. In parts of this type, the flattening effect of a tab is of no help in gating. The greatest problems presented are welds due to deep embossing, deep legend or characters; "Y" close-off where material flows around a rim; and drastic changes of cross section. When such cavities are hobbed, a variation of a few thousandths in the depth of draw could cause non-uniform fill of the parts. This requires much changing of gates and land lengths, and often a departure from the uniform gate size which is desirable in multiple-cavity mold layout.

It was felt that a restriction along the line of flow of the hot plastic material would do two things:

1. It would reheat the plastic material, by narrowing or restricting the flow just prior to entry into the mold cavity. This would give improved physical properties by counteracting the rapid cooling of the hot material as it flows through the runners.
2. Pressures on the plunger end of the machine might be reduced, with a consequent decrease in the possibility of packing.

Generally, the "runner blocks", as we choose to call them, have worked out best if placed in a position two-thirds of the length of the full round runner from the sprue bushing to the cavity. Figure 7 shows how this change was made in an existing horn button mold. A "block" 0.187" in diameter and 0.250" long was placed in the 0.375" diameter runner. This change produced more stress-free parts, with a better surface and, incidentally, increased production.

In the case of a multiple-cavity mold using forked or "Y" secondary runners to place cavities side by side at the end of a common runner, it is best to place the restrictions in the common runner only. The block as placed in such a mold eliminated the "Y" close-off normally encountered in a hemispherical shape as a result of racing of the first material around the rim.

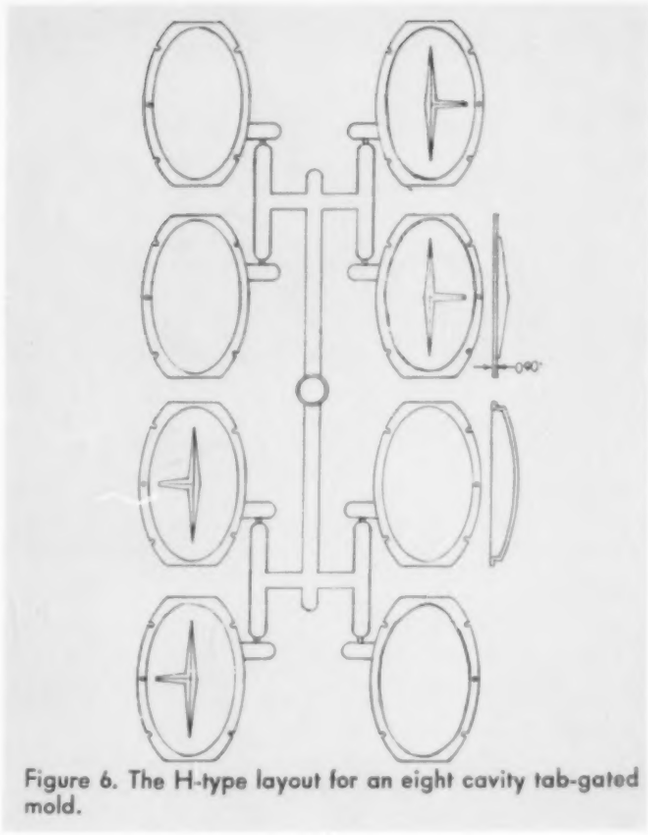


Figure 6. The H-type layout for an eight cavity tab-gated mold.

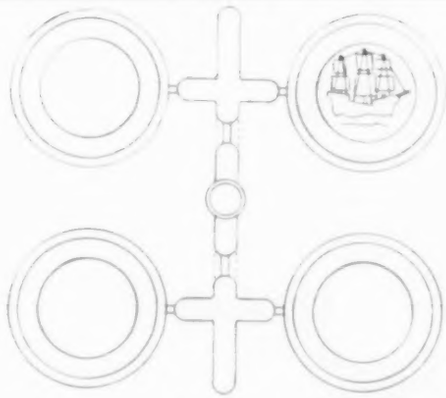


Figure 7. Conversion of existing mold to tab-gate gave better parts, increased production.

Mold Shrinkage

It has been observed in the field that parts molded with tab gates differ in their shrinkage factors from parts molded with conventional gating. The average shrinkage factor usually applied to acrylic is 0.004-0.005" per inch. Some tab gated parts for which the molds were figured at 0.004-0.005" per inch have taken only 0.002-0.003" per inch. It is believed that tab-gating stabilizes the molded part in the cavity because less plunger pressure is usually required to fill the cavity. Further study of mold shrinkage is needed. It is possible that the method of gating described will allow the molder and material manufacturer to reduce the wide shrinkage recommendations now given in technical manuals to a more concrete figure. It is realized that different shaped parts with varying cross sections require different mold shrinkage allowances. The location of the gate in the molded part will also change the shrinkage

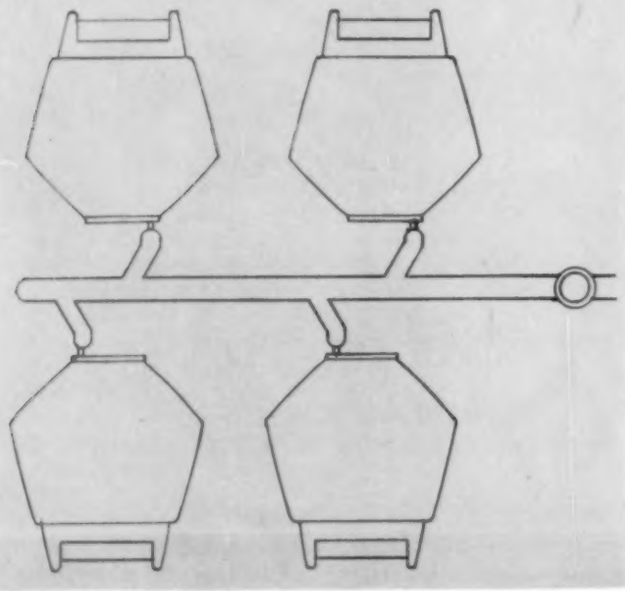
value to some degree. Other factors that affect shrinkage values substantially are mold temperatures and piston forward time.

Delta Wing Runners

It has been the practice for many years to lay out an 8-cavity mold with a main runner off the sprue bushing, then secondary runners facing forward at an average angle of 25-30°. At the end of these secondary runners the gate is cut into the cavity wall, located in a position to minimize welds and other defects. In the study of such runner layouts and the "X" type tab gate as well, it was found that as the plastic moved forward in the main runner a certain amount of "bleeding" of plastic material occurred into the secondary runners. The secondary runners nearest the sprue filled slowly as the material moved forward to the end cavities. Later material "bled" into the end runners. By this time the set of secondary runners closest to the sprue bushing were almost filled. Finally, as pressure built up in the system, all filled. Such a condition caused uneven filling of the cavities with resultant variations in mask fit, weld lines and splash. Secondary runners cut perpendicular to the main runner are only a slight improvement. In order to equalize pressures in the cavities in this type of mold it is necessary to vary individual land areas and gate dimensions to equalize fill. This produces variations in gate set up time at the several cavities, causing irregularities in size and quality of the parts as well as sticking.

In an effort to combat this problem, the flow of plastic was carefully checked in a mold in which the runner pattern was reversed, so that the secondary runners faced backward or toward the sprue bushing. This runner pattern has been called "delta wing." It was found that the material would now fill the main runner fully before branching out to the secondary runners. The secondary runners then fill evenly so that the cavity areas also fill evenly and simultaneously. Thus, it is not necessary continually to balance land areas, gates, and runners to get the best quality parts. Figure 8 shows such a mold layout.

Figure 8. The "delta-wing" runner pattern for tab-gated multiple-cavity mold aids in even filling of secondary runners.



As a corollary to this investigation of runner layout, we have never seen good results from a six-cavity mold wherein the secondary runners branch off the main runner. In such layouts it is the usual practice to place two cavities directly opposite the sprue bushing. These two cavities are always favored in the fill pattern. We have tried all of the gating procedures described with little success. Molds run better in two, four or eight cavities.

Testing Moldings for Quality

A test has been devised to check the stress in acrylic molded parts, as molded, and as annealed. This test involves simply dipping the parts in ethyl acetate and observing them when removed. The test technique is as follows:

1. The molded part under test and the solvent are maintained at 25°C.
2. The molding is immersed in the solvent for:
   a. Two (2) minutes for Plexiglas V, or
   b. Fifteen (15) seconds for Plexiglas VM and VS.
3. The molding is air dried for three to five minutes.
4. The molding is examined for crazing and cracking.

NOTES: **(a)** The moldings should be relatively low in moisture content.

(b) The ethyl acetate should be 98% pure and free of foreign matter.

(c) It is important that the allotted immersion time is not exceeded as this will damage the surface of the molded part severely.

(d) The tested parts must be discarded after examination.

This test has been applied to an assortment of molded parts collected from molders. The results indicate that:

1. Although well molded parts will not craze when dipped in the ethyl acetate bath, poorly molded parts will readily craze when immersed.
2. **A properly annealed part will not craze when solvent-dipped.** The annealed part should be cooled to room temperature before being immersed, otherwise the part will craze severely and, in some cases, rupture.

The test technique described above is submitted as a promising answer to the need for a quick means of determining the probable quality of an acrylic molded part. Ethyl acetate was chosen as the solvent after the characteristics of a number of crazing agents had been compared. There is no information available to correlate the results of this test with the service life to be expected from the parts. Such information would be extremely valuable, but could be obtained only by following the history of a sufficiently large number of moldings. We believe that the test can establish whether one molded part is a better molding than another. Without additional experience the test cannot label a given part as satisfactory or unsatisfactory.

In the various molds we have converted from conventional gating to either tab or restricted runner gating we have had the advantage of testing parts for craze resistance by the ethyl acetate test. Conventionally gated parts craze, generally along the line of flow, in the standard immersion time. Tab gated parts did not craze in the standard time and some parts did not craze even after immersion for 6 minutes. Some slight checking occurred at the sawed edge where the tab was removed. The usual surface-destroying action of the ethyl acetate was not observed in the tab-gated parts even at 6 minutes.

(Please turn to Page 56)

Controlling Effects of Moisture on . . .

Molded Nylon

W. B. Happoldt, A. J. Cheney and E. M. Lacey
E. I. du Pont de Nemours and Co., Inc.

ALL NYLON RESINS are hygroscopic and will absorb moisture from their surroundings until an equilibrium condition is reached. Once at equilibrium the moisture content will change only if the environmental conditions change. The rate of absorption for most moldings is slow because the surface area exposed is small. This is in contrast to molding powder where the surface area is large and the absorption more rapid. Since moisture content influences both the properties and the final dimensions of the part, it is most important to consider these effects in design work.

In many cases parts made of nylon are required to meet certain close dimensional tolerances. Although the dimensional changes with environment occur with all types of nylon, the bulk of these applications are molded from "Zytel" *101 nylon resin, therefore, the data given will be on this type of polymer. Whether these requirements are necessary to the satisfactory performance of the part can only be determined by test or by comparison with similar previous applications. If close tolerances are required, the question then arises whether the parts should be used as molded, should be annealed, or possibly should be moisture conditioned.

Data on the rate of moisture absorption and the effect of this moisture on dimensions are given. Various methods for getting water into nylon in a reasonable length of time are explained along with the advantages and disadvantages of each. It is emphasized that these treatments are only recommended where the presence of moisture in the nylon or the resulting dimensional stabilility is absolutely necessary.

Rate of Moisture Absorption

It is important that the polymer be dry during molding in order to produce parts free from such defects as voids or splay marks. Because of this, parts taken directly from the molding machine will normally contain less than 0.3 per cent moisture by weight. These parts when exposed to air or water will then absorb moisture and the amount of water will increase until an equilibrium condition is reached. The rate of absorption or loss of water is important in that these determine how rapidly parts react to changes in environmental conditions.

The rate of absorption of water by "Zytel" 101 is shown in Figure 1. Of course, a thin section will reach equilibrium more rapidly than will a thicker one. Also parts immersed in water will absorb faster than do those exposed to air. The equilibrium moisture content varies with the moisture content of the environment and is about 8.5 per cent by weight in water and approximately 2.5 per cent by weight in air at 50 per cent relative humidity.

The equilibrium water content is determined only by the relative humidity of the surroundings and is not affected by the temperature. A part that has reached equilibrium will contain approximately the same amount

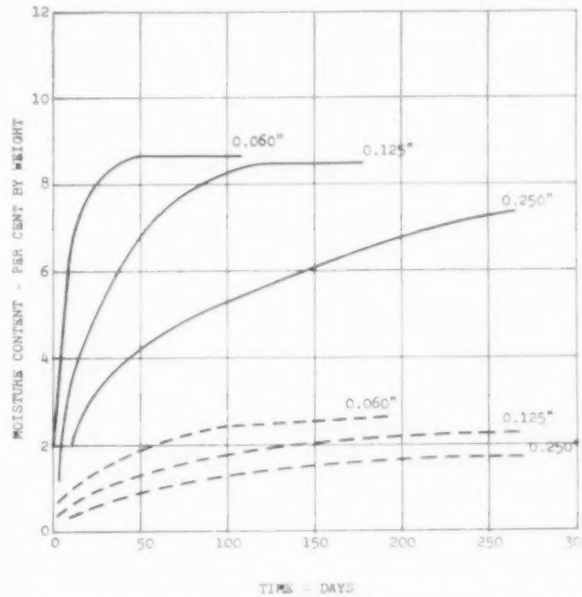


Figure 1. Rate of moisture absorption of nylon parts of various thicknesses exposed to water at 73°F (solid lines) and to air at 50% relative humidity at 73°F (dash lines).

* *Reg. U. S. Patent Office*

of moisture whether it has been exposed to water at room temperature or to boiling water.

The time required to reach equilibrium, however, is dependent upon both the temperature and thickness of the part as well as the amount of water present in the surroundings. A part submerged in boiling water will reach equilibrium much more quickly than the same part in water at room temperature.

Loss of water from a conditioned part when exposed to a dry atmosphere will be just the reverse of the changes described above. The evaporation from the outer surface will be rapid but diffusion from the center will be slow.

For parts in contact with air, it is obvious that, with the moisture content near the equilibrium value, the day to day or even week to week variations in atmospheric humidity will have little effect. Long time changes as between summer and winter conditions will have only a slight effect which will be determined by the difference in the average relative humidities over these long periods.

TABLE I

Effect of Molding Variables on Annealing Shrinkage For Bearings of "Zytel" 101

Bearings 1.000 inches long, 1.034 inches I.D., and 1.250 inches O.D.

VARIABLES*	Annealing Shrinkage—Per Cent Inside Diameter	Length
Mold Temperature °F		
70	1.5	0.6
100	1.3	0.3
150	1.0	0.4
200	0.3	0.1
Cycle Time**		
20–20	1.3	0.3
20–10	1.2	0.4
10–5	0.5	0.3
Ram Pressure—psi		
20,000	1.2	0.4
10,000	1.4	0.0
Cylinder Temperatures***		
600–480–500	1.2	0.4
650–550–500	0.9	0.5
700–550–440	0.8	0.5

* *Other molding variables held constant for each set of tests.*
** *Cycle time—forward and back in seconds.*
*** *Cylinder temperatures—rear, front and nozzle in °F.*

TABLE II

Dimensional Changes in Molded "Zytel" 101 Due to Annealing in Glycowax S932 at 300° F for 30 Minutes

(Bars ½ inch x 2 inches and with thickness as shown below)

Thickness of Bar-Inches	% Change in Length	% Change in Width	% Change in Thickness
0.063	−0.84 ± 0.24	−0.17 ± 0.10	1.32 ± 0.35
0.125	−0.88 ± 0.22	−0.54 ± 0.15	1.40 ± 0.02
0.250	−0.32 ± 0.10	−0.02 ± 0.07	0.48 ± 0.11

In the columns on dimensional changes the first number represents the average change reported as percent of original. The ± figure represents the 95 per cent confidence limits for averages of 15 measurements, i.e., the limits within which the population average should fall in 19 out of 20 cases.

The highest average humidity for a month or more generally will not be above 70 per cent. In cold weather heated air may average as low as 20 per cent relative humidity. Even at these extremes the change in moisture content of "Zytel" is small, because of the very slow rate of moisture absorption.

Effect on Dimensions

There are normally two opposing dimensional effects that occur in molded nylon parts. The first is due to the relief of molded-in stresses and usually results in a shrinkage of the major dimensions. The second effect is an increase due to moisture absorption as described above. The sum of these two effects determines the total change that will take place.

Changes Due to Stress-Relief. The magnitude of the stresses in a part depends on the molding conditions. This is shown in Table I which gives the dimensional changes of a simple sleeve bearing on annealing at 350°F. For our purpose here it is sufficient to point out that annealing does produce changes and that these do vary significantly in the different dimensions.

The magnitude of the changes that occur on annealing of a rectangular bar under one set of molding conditions is given in Table II. In general the long dimensions will decrease but thin sections may increase. For any specific case, the change in size due to relief of stress can be determined by measuring and annealing a few trial pieces.

Annealing is simply a heat treatment in an oil or liquid medium at a temperature 50°F or more above the maximum exposure temperature to be encountered. For parts to be exposed over a wide range of temperatures, annealing at 300 to 350°F is usually recommended. A hot water or steam treatment, as described under Moisture conditioning, not only adds moisture but is an effective annealing procedure for applications where the service temperature will not exceed the conditioning temperature. Once annealed "Zytel" will be free of dimensional changes due to stress-relief below the annealing temperature.

Changes Due to Moisture Absorption. In contrast to the variable change due to stress-relief, the effect of absorbed moisture under equilibrium conditions on the dimensions is always predictable for stress-free (annealed) parts. The effect of the moisture content on the dimensions of a part of "Zytel" 101 is shown in Figure 2. These data are for the annealed or stress-free condition. For average applications in air final dimensions correspond to those obtained in equilibrium with 50 per cent relative humidity. As shown, "Zytel" 101 will increase 0.006 inch per inch. In many applications this change is small enough and occurs so slowly that it does not affect the operation of the finished parts.

Stress-free parts of "Zytel" 101 changing from dry to completely saturated with water will increase approximately 0.026 inch per inch. In water service, if dimensions are critical, the part can be moisture conditioned before assembly to allow for this change. Procedures for moisture conditioning are discussed below. Once at or near saturation, the dimensions will change very little unless the part is allowed to dry for long periods.

Typical Changes in An Air Environment

The dimensional changes discussed above are for the annealed or stress-free condition. Actual measurements of parts that have not been annealed when exposed to air often actually show a change of less than 0.002 inch per inch in going to equilibrium. The smaller increase in dimensions results because some shrinkage due to stress-

relief is taking place at the same time that moisture is being picked up from the air. An example showing this effect for a typical set of conditions is covered in the following paragraph and example A of Figure 3. This analysis has been found to fit cases examined in the course of our work. Additional data are being obtained to more accurately explain this stability.

A part with a 1.000 inch dimension would normally increase 0.006 inch due to moisture absorption as shown by the top line of example A, Figure 3. This occurs either in an atmospheric environment averaging 50 per cent relative humidity or in air controlled to this condition. The example is based on a one-eighth inch thick section which would reach equilibrium in about one year. During this time, however, stress-relief and slight changes in the polymer structure will occur tending to reduce the dimensons. The size of this reduction will vary depending on molding conditions but normally averages 0.005 inch per inch. Therefore, this shrinkage might be represented by the lower dotted line. The result for this example is a net increase of 0.001 inch as shown by the center line.

The previous paragraph explains the small dimensional change of parts that stress relieve themselves over a period of time while moisture is being absorbed. By contrast, stress-relief and resulting shrinkage will occur if the part is exposed to a higher temperature before it has an opportunity to pick up moisture. This is a time-temperature phenomenon in that a few minutes at 300°F or possibly several days at 160°F may produce the same effect. Where stress-relief will occur and the dimensional change will affect the performance, parts should be designed so that after annealing they will be at the correct size. Then if exposed to an air environment, the part will pick up moisture in the normal manner and behave as shown in example B of Figure 3. It is also possible to speed up the moisture absorption by moisture conditioning, but this is seldom required for those parts intended for use in air.

Change with Varying Environment

After the part has been sized initially, it is often important to know how changes in environmental conditions will affect dimensions. Both moisture and temperature effects can be estimated from the data of Figure 4. Starting with stress-free or annealed parts after molding the dimensions will increase as shown by the various relative humidity lines. The zero point has been taken at room temperature. The temperature effect can be determined from the data given or the change with temperature can be calculated easily from the thermal coefficient of expansion. It is 0.00005 inch per inch per °F.

Conditioning Techniques

In any conditioning operation, two points are of major importance:

First:—How long does it take to reach the desired moisture content?

Second:—How does the conditioning affect the properties of the molded part?

The rate at which moisture is absorbed depends on both the thickness of the molded part and the temperature of the conditioning step as pointed out earlier. This temperature dependency can be readily seen in Table III which shows that the moisture level reached in 4 days at room temperature can be obtained in 100 minutes at 212°F.

From a practical consideration, therefore, it is highly desirable to carry out the conditioning step at an ele-

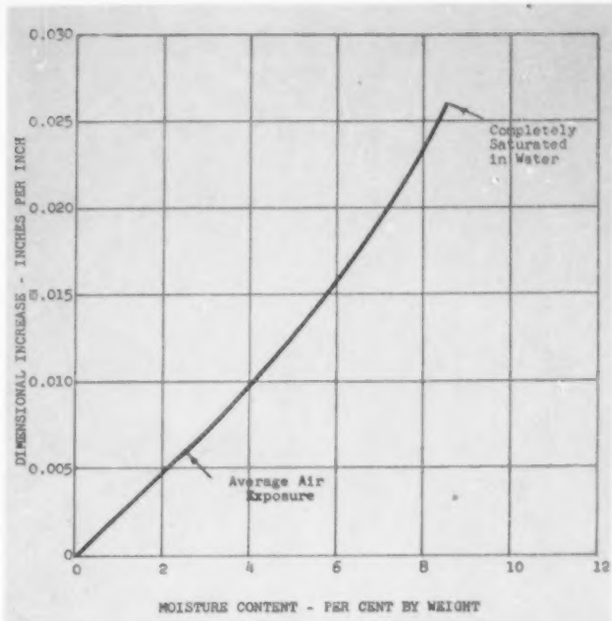


Figure 2. Change in dimensions with moisture content of Zytel resin.

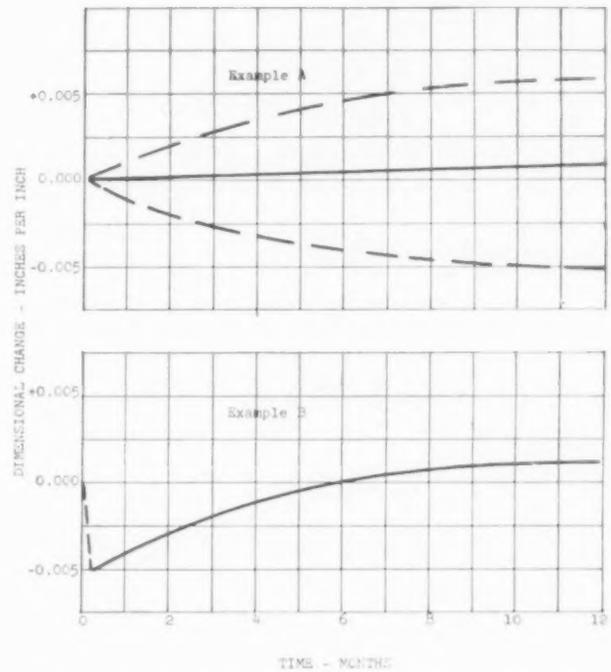


Figure 3. Typical dimensional changes of one-eighth inch thick sections of Zytel when exposed to air at 73°F and 50% relative humidity.

TABLE III

Effect of Temperature on the Rate of Moisture Absorption of Molded, 1/8" Thick "Zytel" 101 Immersed in Water

Temperature °F	Time to Absorb 2.5% Moisture
73	4 days
212	100 minutes

Water Absorption Data

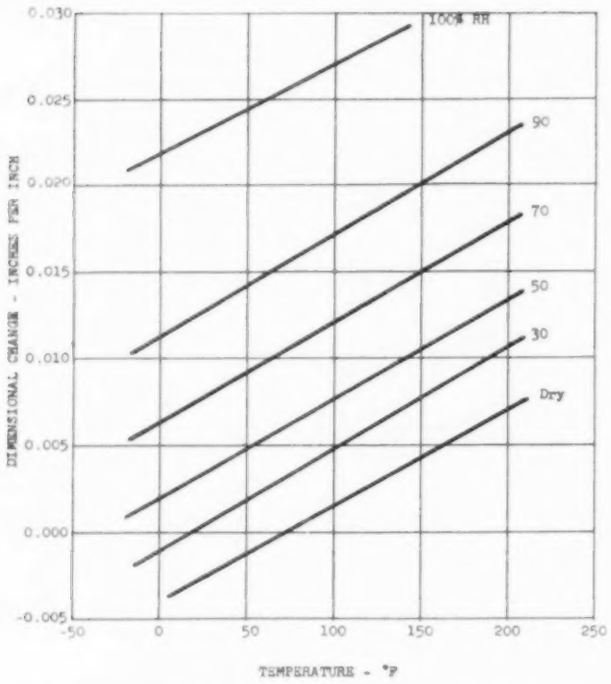


Figure 4. Equilibrium dimensions vs. temperature and relative humidity.

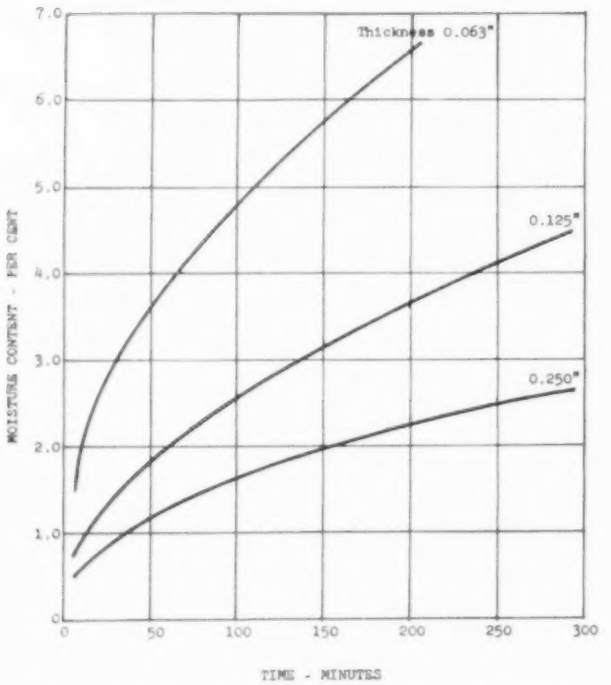


Figure 5. Rate of moisture absorption of Zytel in boiling water.

vated temperature. Several approaches are possible and include:

(1) Boiling in water to partial saturation
(2) Heating in a salt solution such as potassium acetate and water, or
(3) Conditioning in superheated steam either at atmospheric conditions or under pressure.

Each offers certain advantages and disadvantages.

Conditioning in Boiling Water

Of all the procedures, boiling in water is the simplest and easiest to do. Furthermore, it requires little investment in equipment other than a heated container preferably with a controller for the water level. Because of its simplicity, this method is widely used today by commercial molders.

The boiling water technique does, however, have a serious drawback, i.e., it is difficult to control the quantity of water that will be absorbed. The outer surface will absorb the equilibrium quantity of 8.5% water while the center will contain much less if the part is to pick up a total of 2 to 3% by weight. Also, the amount of water absorbed in a given time does vary with thickness and since we are boiling for a period long enough to bring the average content of the part to say 3%, the thinner parts of a molding will obviously absorb more than the desired 3% of water. This usually is not a serious problem, but does mean that the stiffness of these thin portions will be lowered considerably initially. This effect is demonstrated in Figure 6. If the part is subsequently used at 50% relative humidity, the thin portions of a high content will rapidly drop to the desired 2-3% level.

The question immediately arises as to what is meant by "thicknesses" in an article of varying geometry. In this and in all other slides the word "thickness" is intended to mean the smallest dimension of the section.

Conditioning in Salt Solutions

By contrast, the water content of molded articles of "Zytel" can be controlled precisely if the parts are boiled in an aqueous salt solution having a partial pressure equal to the 50% relative humidity which they will encounter in average air applications use. This technique is also relatively easy, but is more difficult to do than the boiling water method and does require some outlay for equipment. It is not yet used commercially to our knowledge, but has been used at the Sales Service Laboratory to condition many samples for tests which would be affected by fluctuations in water content.

In our laboratory we have followed the method first proposed by Ecochard and Berchet.[1] A solution is first prepared by dissolving 1.25 parts by weight of potassium acetate in 1.0 parts of ordinary tap water to give a solution corresponding to 55.6% of salt. The molded articles are placed in this solution and boiled at 250°F until they reach equilibrium after which they are removed and rinsed well with water.

As with the boiling water technique, the amount of water absorbed in a given time varies with the thickness as shown in Figure 6. Note also that these parts reach an equilibrium at about 2.5% water content. This is equivalent to that picked up at 50% relative humidity and contrasts with the saturation value of 8.5% water that the parts absorb on prolonged boiling in plain water. Furthermore, should the user of the potassium acetate method overcondition his parts they will never absorb any more than the 2.5% equilibrium value. Since this is an equili-

[1] *Ecohard and Berchet, "Industrie Plastique Moderne," 8, 1956, p. 33*

brium value, the water is uniformly distributed throughout the part.

It is also obvious from the curves in Figure 6 that the samples of different thicknesses will not always reach the same, absolute water content. This, we believe, is due in part to the fact that the samples vary in crystallinity because of differences in their rates of cooling in the die during injection molding. If this is the case, the thinner and less crystalline samples should absorb more water as the amount of water absorbed at 50% relative humidity will vary from 2.7 to 2.4% as the crystallinity changes from 25 to 35%.

This salt solution technique also has its disadvantages. For example, the solution is strongly alkaline and corrosive and has to be used in stainless steel equipment. Furthermore, the salt concentration has to be maintained at a fairly constant level via either a reflux condenser or a density control. Since a small quantity of the potassium acetate remains absorbed on the surface even after rinsing, this method of conditioning should not be used on parts intended for electrical equipment where the loss factors of "Zytel" are important.

Normal boiling in the salt solution does not appear to affect other physical properties, listed in Table IV, although there does seem to be a downward trend in viscosity with prolonged heating. This emphasizes that "overconditioning" should be avoided in this and the other methods for conditioning.

Conditioning with Steam

More recently, we have been studying the possibility of using steam to condition the articles molded from "Zytel." This approach is possible for an atmosphere corresponding to a relative humidity of 50% and can be achieved by using superheated steam at a temperature at which its absolute pressure is one half that of saturated steam. In practice, it is necessary to adjust this pressure slightly from the theoretical to produce the desired moisture level because the assumption that the equilibrium moisture level of nylon at a given relative humidity level is independent of temperature does not appear to be strictly true. Thus, at a steam pressure equivalent to that of 54 rather than 50% relative humidity was needed to get a 2.5% moisture content in molded "Zytel" 101.

Whether one uses steam at atmospheric conditions or under pressure, the technique is the same: i.e., the samples are exposed to the superheated steam in a semi or completely closed vessel. Under atmospheric conditions, the temperature is approximately 250°F and at 9 psi it is 271°F. Under either condition, all of the air must be completely swept from the equipment and air-free steam must be used or oxidation and degradation of the nylon will occur.

Because of the necessity of generating and handling steam, these methods require more equipment than the others. By contrast, the 9 psi steam method is the fastest method for introducing moisture as illustrated in Table V which compares the times to equilibrium for the salt solution technique with those of the atmospheric steam and pressure methods.

Which Method to Use

At this point, it should be reemphasized that no conditioning is necessary in most applications of "Zytel" in air due to the fact that the parts rapidly absorb enough water from the air to increase the toughness of the part after molding. Also, the dimensional changes that will occur in an unconditioned part of "Zytel" are usually too small and occur so slowly that they do not affect the performance.

In the case of molded articles intended for either full or part-time service in water, it is often necessary to condition the molding to the proper dimensions prior to installation. This can best be done by either simply soaking or by boiling in water. The latter is much faster.

In the case of molded articles which will be used in air, the situation is slightly different for many of the articles intended for this type of service can be used "as

(Please turn to Page 62)

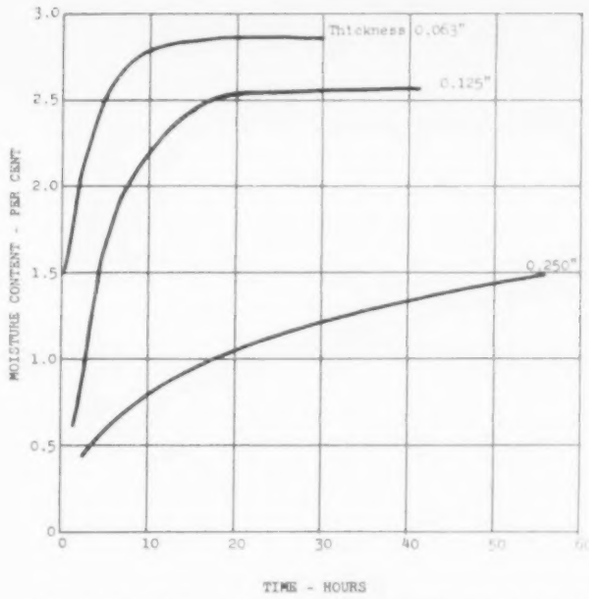


Figure 6. Rate of moisture absorption of Zytel in boiling potassium acetate solution at 250°F. (1.25 parts by weight of potassium acetate to one part of water.)

TABLE IV

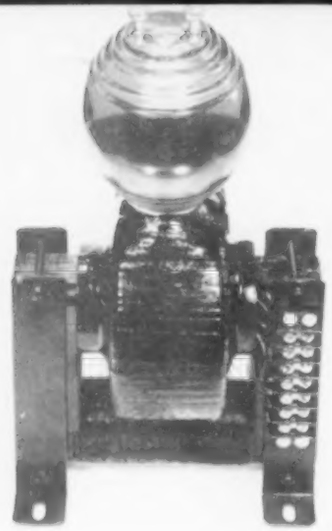
Effect of Conditioning in Potassium Acetate Solution On Properties of "Zytel" 101
Samples Dried to Less than 0.1% Moisture Before and After Conditioning

	Initial	Conditioned 24 hours	Conditioned 72 hours
Tensile Strength, psi	8,000	7,800	7,800
Tensile impact ft. lbs/in²	78	78	76.5
Mandrel bend (180°–breaks per 25 bends)	None	None	None
Viscosity, inherent	1.26	1.24	1.21

TABLE V

Time Required to Condition Parts in Steam Or Potassium Acetate Solution

Minimum Thickness Inches	Hours in Steam or Potassium Acetate at 250°F	Hours in Steam at 270°F
1/8	20	9
1/4	80	36



The Use of Plastics in High-Energy Nuclear Research

James O. Turner

Radiation Laboratory, University of California

The Radiation Laboratory at Berkeley presently boasts the highest-energy accelerator in the free world, the Bevatron. Many different kinds of nuclear particles have been produced, accelerated, transmuted and studied in this and other accelerators. The press recently announced the finding of the antiproton and antineutron, particles of matter created out of pure energy in experiments with the Bevatron.

A very ticklish business is this pursuit of the antiproton and the antineutron, as well as of the neutrino and the meson. One has to learn how they are created, and how they live and die; what they are like—charge, mass, spin, and magnetic moment, (the nuclear scientist's equivalents of habitat, color, song, and mating habits)—and what they do to other particles and other materials that get in their way when they are traveling at velocities near the speed of light. Some of these live for only a few microseconds, and some predicted ones haven't even been found yet. Guiding them requires powerful magnets, and their creation may require billions of electron volts. This means that voltages, magnetic forces, vacua, and energies have to be pushed higher and ever higher. To achieve this necessitates continuous invention and development of new ways to attack the problems.

New Techniques—New Materials

The new techniques in turn require ever more and more specialized materials of all sorts. A vital and indispensable role in this effort is performed by plastics for electric isolation, radiation detection, and containment. These all have to operate under one or more of such tough, exacting conditions as higher radiation fluxes, with much highly penetrating gamma radiation, vacua of 5 x 10^{-6} mm and better, gigantic magnetic forces resulting from fields of up to 25 kilo-gauss in continuous operation, and some pulsed ones many times this value, voltage gradients up to 20,000 volts per inch, and extremes of temperatures up to +450°F and down to −424°F.

Thanks to the genius of the chemical and plastics industries and some adroit applications by ingenious nuclear design and materials engineers, solutions have been found to some of the knottiest of these problems.

One of these problems is the focusing of the beam in a particle accelerator. Particles to be accelerated usually begin their journey by being ionized or stripped of electrons in what is known as an ion source or injector, which operates in the range of several hundred thousand volts. As the particles start on their journey toward the accelerating zone, their stream must be focused into a narrow beam. Figure 1 shows an electrostatic

Figure 1. Cast epoxy insulating rings.

focusing lens consisting of two 6-inch diameter cast epoxy insulating rings and a center metallic electrode, all cemented together with epoxy cement. This assembly must hold a high vacuum on the inside, and the plastic rings must withstand 30,000 volts across their 1-inch width.

Ion sources and other pieces of apparatus frequently contain electronic tubes with heater filaments that operate at a high voltage above ground. The transformer coil that powers the filament must be insulated for this high voltage. Figure 2 shows the secondary coil of such a high-voltage filament transformer deeply imbedded in an epoxy casting.

The termination of a cable that operates at high voltage is a problem because of the high gradients encountered where the conductor emerges from its insulating sheath. A clear epoxy casting was used successfully to distribute and withstand these gradients with a cable operating at 235,000 volts dc. An epoxy casting whose dielectric constant had been adjusted by addition of glass bead filler served the same purpose for a cable operating at half million volts dc.

Figure 2. High voltage coil embedded in epoxy resin.

We are repeatedly faced with the problem of carrying electrical circuits through the walls of vacuum vessels operating at pressures around 5 x 10^{-6} mm of mercury or less. This requires bushings that are vacuumtight, do not outgas, and will withstand high voltage, and frequently re-

quires that they have high mechanical strength as well. Figure 3 illustrates a bushing for such an application, which has been fabricated of glass cloth and epoxy resin. Merely getting a high-voltage circuit through a grounded case sometimes becomes a problem when one is severely restricted for space. Bushings are constructed of epoxy resin filled with glass beads for use in transformer cases. They carry circuits ranging up to 100,000 volts to ground. Figure 4 shows the internal construction of one of these bushings.

Figure 3. Vacuum-tight bushing of glass and epoxy.

The problem of quickly inserting a target into the accelerated beam of the Bevatron was solved by the use of a coil that would interact with the magnetic field of the Bevatron itself. This coil is so positioned in the magnetic field that when it is quickly energized by an external source of current it must rotate through 90° to align itself with the field, thus driving the target into the accelerated beam. These coils were constructed on a form machined from acrylic plastic. After the coil was wound, it was tightly taped with a glass cloth tape, which was then saturated with an epoxy resin and cured. The coil was then filled with epoxy resin by means of a veterinarian's syringe, after which it was cured and ready for use. (This is shown on the cover.)

Magnetic Coils

Our kind of operation requires magnets of every conceivable size, shape, and description. Some of these are used for the purpose of focusing a beam of particles, keeping it in "the straight and narrow path." These coils are wound of square copper conductor with a hole in its center for water cooling. The conductor has cotton sleeving slipped over it, and is then dip-impregnated in vacuum with epoxy resin. These coils are used frequently inside accelerators at high vacuum. A coil constructed in the same manner of water-cooled square copper conductor, this time for a 60-inch-long magnet was first cocooned by wrapping with glass tape and coating with epoxy resin, and then was filled by vacuum-pumping one end and pressure-injecting the resin at the other end.

In some investigations the magnetic and other forces become exceedingly high and the copper conductor must be reinforced with something that is a nonconductor but still has the highest possible mechanical strength. Figure 5 illustrates a coil for an application of this sort, which has been constructed of ⅜-in.-square water-cooled conductor, backed up both inside and out with fiberglass roving and cloth, all epoxy-impregnated. Electrical and water connections are made to these coils by drilling and tapping into the side of the conductor near its end.

Even the lowly sandbag is a useful device when it becomes necessary to shield personnel from low-energy radiations emanating from piping. A sandbag containing wet sand is made of heavy-gauge polyethylene film sealed with a hot-air gun. The sandbags solved a difficult problem of shielding in a very restricted space.

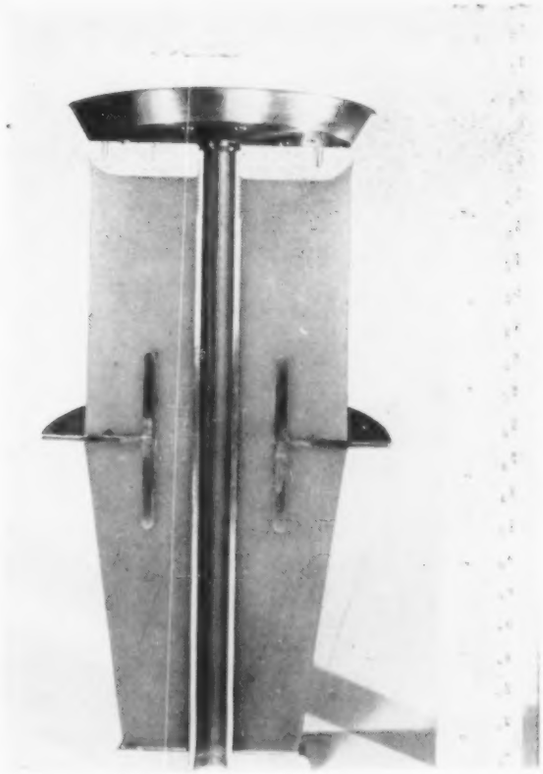


Figure 4. Transformer case bushing made to handle 100,000 volts.

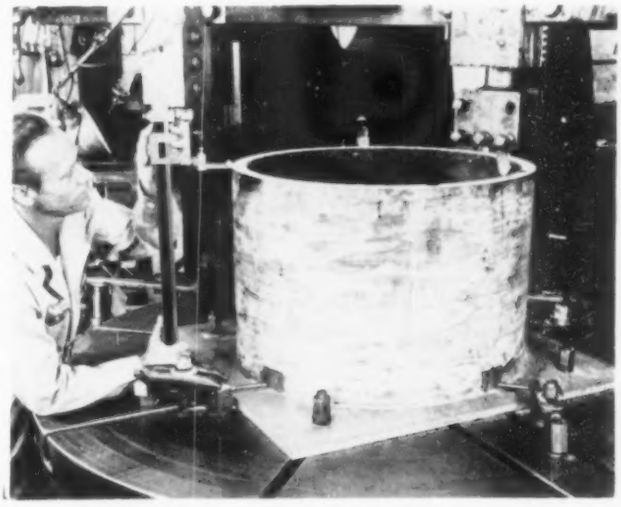


Figure 5. Reinforcement for water-cooled conductor is fiberglass-epoxy resin.

A great many experiments are based upon collisions of a variety of accelerated particles with protons. In order to get the highest density of protons—that is, the greatest possible number in a given volume—we make use of a considerable amount of liquid hydrogen, whose nucleus consists of a single proton. Since liquid hydrogen boils at approximately −453°F, there arises the

Plastics Parts in Nuclear Research

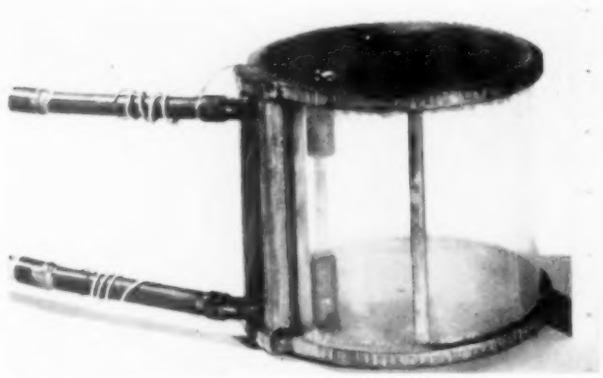


Figure 6. Liquid hydrogen container made of polyester film and brass.

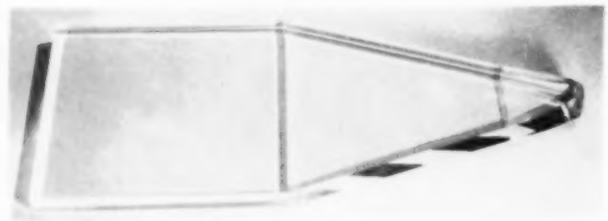


Figure 7. Acrylic "light pipe."

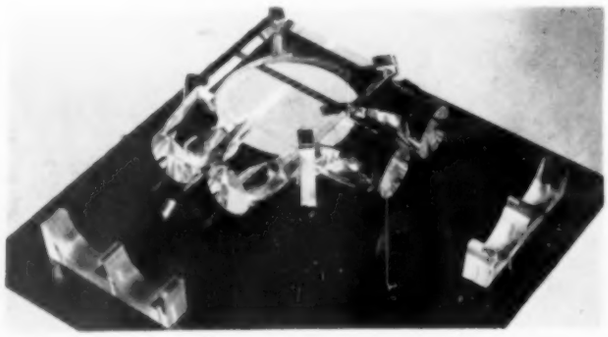


Figure 8. Acrylic Cerenkov counter.

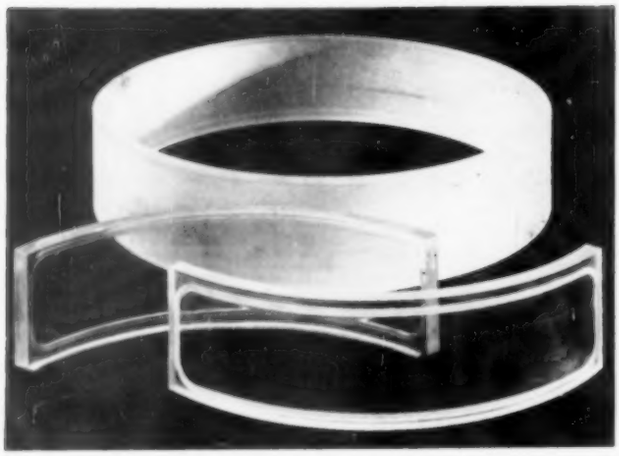


Figure 9. Cloud chamber windows of cast polyester withstand thermal shock.

problem of building a container to insulate it as well as possible and at the same time to obstruct the incoming beam with as little mass as possible. A liquid hydrogen container is constructed so that as the liquid evaporates, the cold hydrogen gas passes out the top of the inner container, down between the walls of the inner and outer containers, and out through the hole at the bottom. This blanket of cold hydrogen gas reduces considerably the heat reaching the inner container from the walls of the outer container. Containers of this type are presently made of expanded styrene, and we are studying the possibility of using some of the "foam in place" polyurethanes for this purpose.

Polyethylene Liner

A polyethylene liner for a liquid hydrogen target container of a somewhat different shape is constructed of 20-mil material, with an insert or window of 2-mil material near the bottom. Sometimes these liquid hydrogen targets have to be used inside the vacuum envelope of the accelerator. In this case we exchange one problem for another. There is no longer any need for heavy insulating walls, but now we must construct a vessel that is completely vacuumtight, and of a material which does not outgas. Figure 6 shows a liquid hydrogen target container for use in a vacuum. This one is constructed of 7.5-mil polyester film cemented to brass with an epoxy adhesive.

The large-scale detection and counting of radiations is a problem unavoidably associated with large-scale nuclear research. A material that lends itself most admirably to accomplishing this purpose is the plastic fluor, or scintillator, which emits visible light under the influence of radiation. As the magnitude of this problem increased, it became necessary to develop a technique for producing these fluors in ever larger and more massive blocks. The manufacture begins with styrene monomer, to which is added an "activator" which is 2 to 3% by weight. This material is poured into the bottle, which is then placed in an oil bath, heated by means of steam coils. The activator dissolves in the styrene, which is then polymerized by a very carefully controlled elevated temperature. After polymerization, the bottles are removed from the oil bath and quickly incased in a heavy mass of fiberglass insulating material. They are allowed thus to cool slowly for several days, after which the bottle mold is broken and the plastic ingot is ready for machining.

Acrylic as a Fluor

For actual use, this fluor material is fabricated and shaped in a variety of ways. One technique involves pressing out slugs of this material to form wide, flat sheets.

In an assembly using a number of these sheets, one end consists of a stack of six of these sheets interleaved with lead sheets approximately 1/32 inch thick. Cemented to one of the edges of this stack of fluor plates and lead is a block of acrylic plastic, and beyond that is the housing for a photomultiplier tube. The photomultiplier tube looks through the acrylic light pipe at the edges of the fluor sheets, and thus receives light from their scintillations. This assembly is one of many similar cells that have been stacked up into a large assembly for an antineutron experiment. The axis of the beam or radiation is at right angles to the plane of the fluor sheets. Figure 7 illustrates a somewhat similar application, but without any interleaving lead sheets. The fluor material on the left in this case is 12 inches square

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Engineering of Molds Using Electroformed Cavities

W. J. B. Stokes, II
Electromold Corp.

. . . designing a plastics mold calls for full knowledge of possible metals and methods of construction. The electroformed mold cavity has advantages in many applications.

ELECTROFORMING DIFFERS from all other mold making methods in several important respects. One basic difference is that electroforming starts with the shape of the cavity and builds metal **around** that shape, while other methods of cavity construction start with a mass of metal and form a cavity shape **in** it. In electroforming there is no mass of metal to begin with, and time is required to build that mass. It is therefore desirable to use as little metal as will properly do the job. Adding excess metal is a waste of time and money. In determining the amount of metal required in an electroformed cavity, we calculate only the wall thickness necessary to assure adequate strength for the molding conditions. Electroforming deposits metal quite evenly around the master so that the outside of the rough electroform is merely an exaggeration of the shape of the master. This, as we shall see, causes some difficulties in attaining certain outside dimensions and makes necessary some mold design modifications.

First let us consider all of the characteristics of electroformed cavities which pertain to the engineering of molds. Two types of electroforms are in general use today. One might be called American style and the other English style. The American method is to electroform an all-nickel cavity having a relatively thin inner layer of hard nickel, with the mass of the cavity built-up with soft nickel. The English method is to use an inner hard nickel layer about 3/16th" thick backed-up with hard copper of about 220 to 250 Brinnel. The two constructions are shown in Figure 1. Also in this figure are demonstrated the variations in the rough outside shape of the electroform due to the differences in plating technique.

Electroformed Metals Differ

Electroformed metals are different from rolled or cast metals, and in many ways more nearly resemble the vacuum cast metals. Variations in the composition of plating baths and plating techniques can make great differences in the electroformed metals. Each electroformer must select for himself the combination of characteristics that he feels will be most suitable for use in molds. In the English style cavities, with which the writer is most familiar, a hardness of 450 to 500 Vickers has been selected as a result of experience over the years. At this hardness the electroformed nickel is exceedingly ductile; in fact one English aircraft firm has termed this material the most ductile material of its hardness they have ever seen. The combination of good hardness and high ductility indicates a tremendous ability to recover from deformation, and that characteristic has been very evident in our experience with these cavities. In many instances these nickel cavities have out-performed other materials having substantially greater hardness. We have seen molds where sprue stringers were pulled across the nickel cavity faces continuously without damage, although of course this procedure is certainly not recommended. We have used these cavities in automatic closure compression molding machines where millions of pieces have been produced with no failures of the land areas. Such a performance is remarkable for cavities having a hardness which is generally considered too low for the purpose. The secret of their performance, however, lies in their resilience.

High Heat Conductance

Another characteristic that should be noted in the English style cavity is the very high heat conductance of the outer copper layer. Pure copper has a heat conductance about four times that of the best of other mold materials. This means that these cavities, **if given a chance,** will cycle much faster than any other cavities. Careless design or the desire for cheap construction may set up all sorts of heat barriers between the cavities and the cooling channels.

Another characteristic of interest to the engineer is the corrosion resistance of the cavity surface. Vinyls and the fluorine bearing materials can be molded in these cavities

Figure 1. Construction of electroformed cavities. Outline of conventional cavity shape.

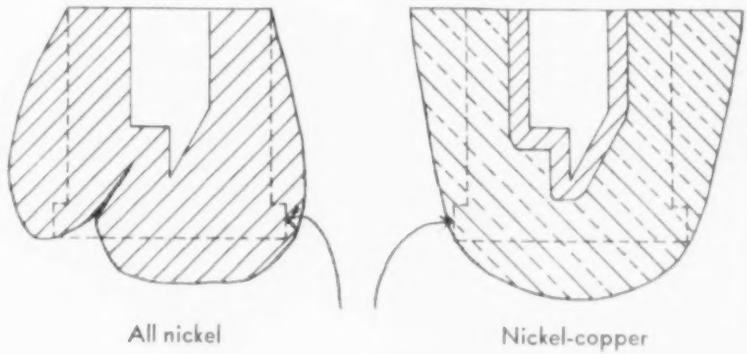
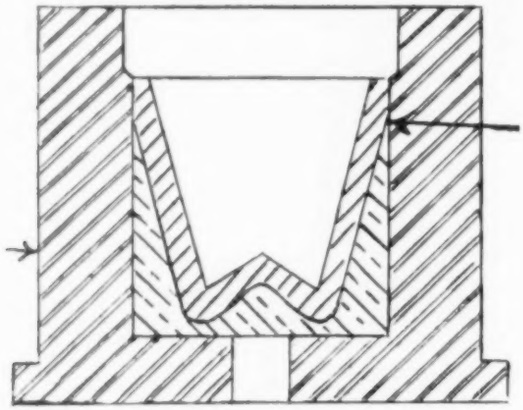


Figure 2. Compression mold cavity.



Arrow at left indicates steel block and arrow at right shows the electroformed insert.

without further protective plating. These cavities will not corrode during storage, or if they are idle in a working mold. The nickel surface provides excellent release with polyethylene, and permits this material to be molded with a shiny surface, where the use of other cavity materials would require a vapour blast finish resulting in a dull molded surface.

One contradictory thing about nickel cavities is that they have a tendency to stick with thermosetting materials and whenever they are used with these materials, they must be chrome plated. The nickel surface is a perfect base for chrome, and cavities so treated give excellent service.

Let us consider now how electroformed cavities are used in molds. We refer to our earlier comment that excess metal in an electroformed cavity is costly in time and money. It is therefore desirable to design the cavity mounting in the mold in such a way that excess metal build-up will not be required. Let us again look at Figure 1 which shows the outline of an electroformed cavity ready for machining, and the shape of the cavity that can be machined from that rough electroform. You will note that only a certain cavity height can be cut from the electroform. If a greater height of cavity is required much more metal would be needed. For many shapes of pieces the design of the mold should, where possible, be modified to accept a cavity whose height is commensurate with the inside depth of the cavity. Often this is not practical or desirable. Figure 2 shows a conventional cavity-retaining construction with cavity plate and retainer plate, which in this instance also has the cooling channels. The solid cavity as shown on the left in this figure is impractical for electroforming. Consequently we would make the cavity as shown on the right where we have turned up a steel sleeve and shrunk the electroform into it. Sometimes it is desirable merely to fit the electroform into the sleeve and retain it in the sleeve with screws from the bottom. This is a frequent construction of electroformed cavities and requires no change in mold design from the conventional.

In Figure 3 are shown two preferred methods of mounting these cavities. On the right is a cavity having a retaining shoulder at the top of the cavity plate. The shallow electroform is held up against the shoulder by a plug set in back of it. In this construction the electroform is more easily and cheaply replaced, and original cost is lower. On the left in this same figure is a preferred construction. Here the cavity retainer plate is completely eliminated. The electroform is set into a pocket in the cavity plate and held there by a screw or two from the bottom. Water channels are in this same plate.

The placement of cooling channels is important. Often the water channels are put down into a retainer plate as in Figure 2. In this construction the heat has to go through two metal discontinuities which are essentially heat barriers. In such a mold the added heat conductance of the copper shell does not have a chance to show its stuff. The steel with its low heat conductance rate cannot get the heat of plasticization to the water channels as fast as the copper can draw it from the cavity surface. The preferred construction shown in Figure 3 not only is cheaper to mount, but will also result in lower molding costs because it will cycle faster.

Small cavities of fairly regular shape can be electroformed sufficiently thick so that they could be cut into a reasonable geometric outside shape. For such large cavities where this is not always possible, three methods are used in retaining the electroformed shells. The most costly but best method is to take a cast of the outside of the cavity and duplicate this shape into a cavity plate. This method is the customary one for cavities over 100 square inches in area. For cavities under that size we generally use one of two other methods. If the cavity is not too irregular, we machine it to nearest reasonable geometric shape and then machine a pocket to fit. Such a construction is shown on the left of Figure 4. Another solution to the problem is to take a cast of the back of the cavity, (generally plaster is used for the purpose) and to reproduce this plaster pattern in a metal casting. The metal generally used is a high tensile manganese bronze. By

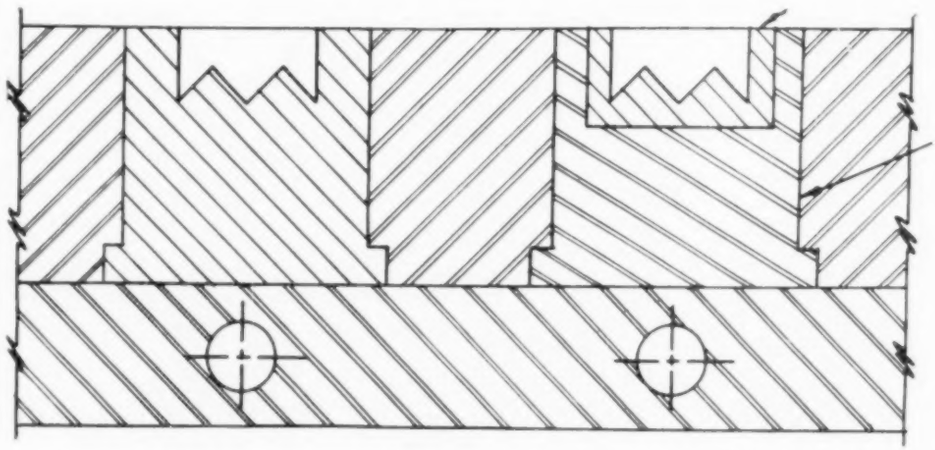
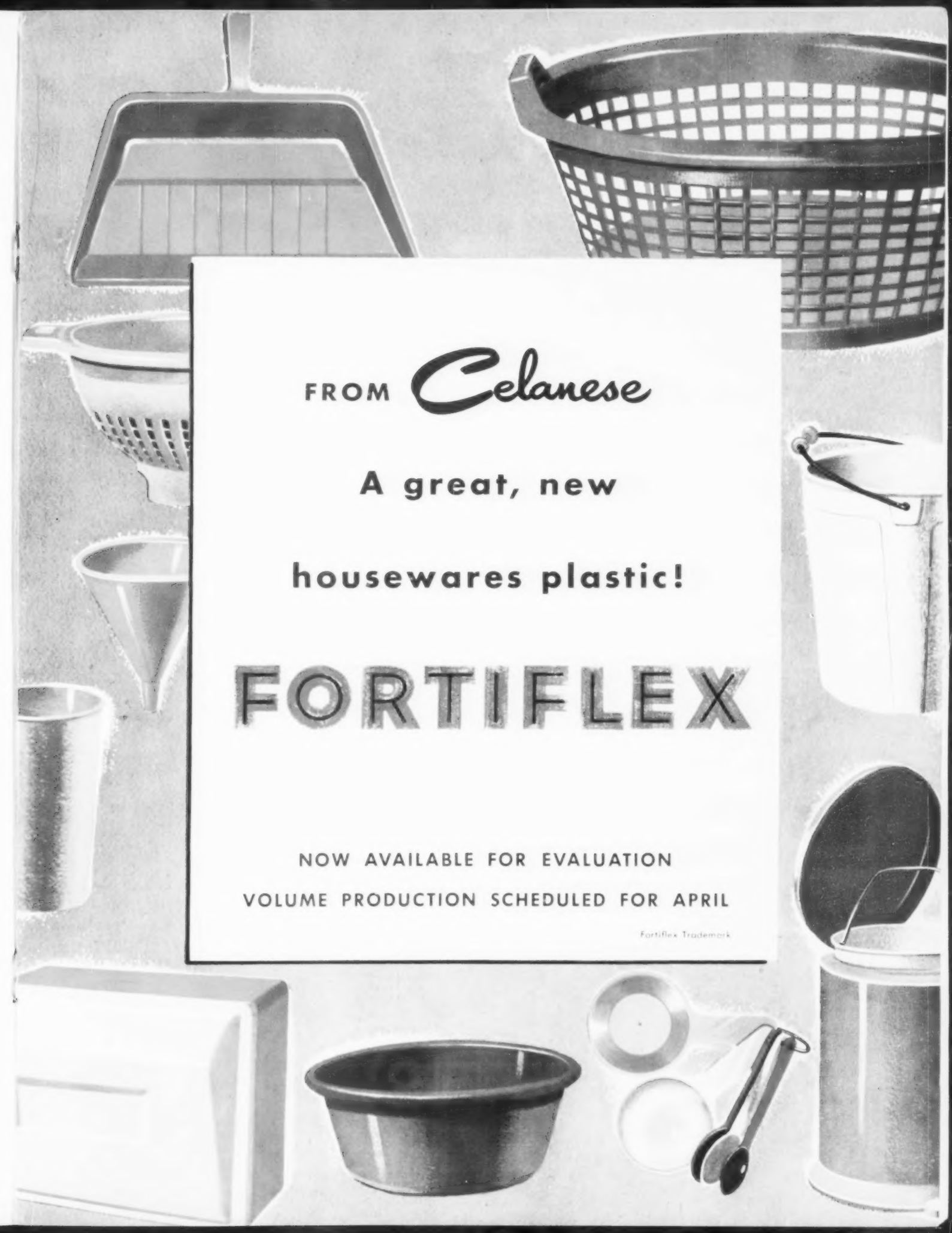


Figure 3. Methods of retaining electroformed cavities for small regular shapes. Shown are solid and sleeved cavity plate and retainer-plate construction.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This means that for the first time the housewares industry will be able to offer the consuming public tough, colorful housewares that hold their shape and can be immersed in boiling water . . . resist harsh chemicals . . . stand up to punishing handling.

Being rigid as well as tough, housewares designed of Fortiflex will not require extra thick supporting wall sections or heavy roll edges to obtain rigidity. This will result in economies in the use of material and contribute to lighter weight items.

Resistance to sterilization temperatures will broaden the applications for Fortiflex in housewares and containers. Such articles as nursing bottles, and other products requiring sterilization can be made of Fortiflex, and high water temperatures will prove no threat to the form retentive qualities of Fortiflex bowls, cups and other containers.

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You will want to know more about Fortiflex, and when this brilliant, new material will be available in full volume. You will want to test Fortiflex *now*, in order to take advantage of its superior properties just as soon as possible. We suggest that you get in touch with Celanese at once. Arrangements can be made to ship quantities for evaluation, and to provide you with expert technical advice and assistance. Write or call Sales Development Department, Dept. 179-A, Celanese Corporation of America, Plastics Division, 290 Ferry Street, Newark 5, N. J.

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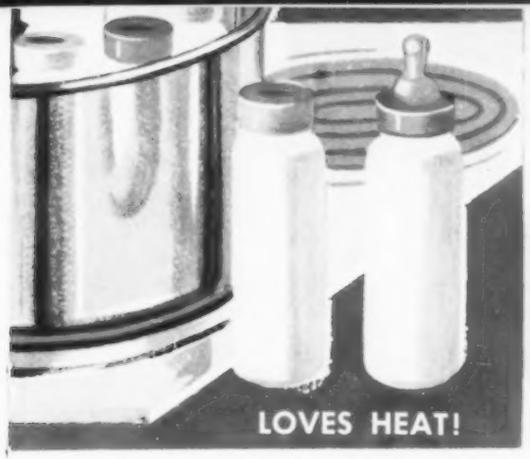
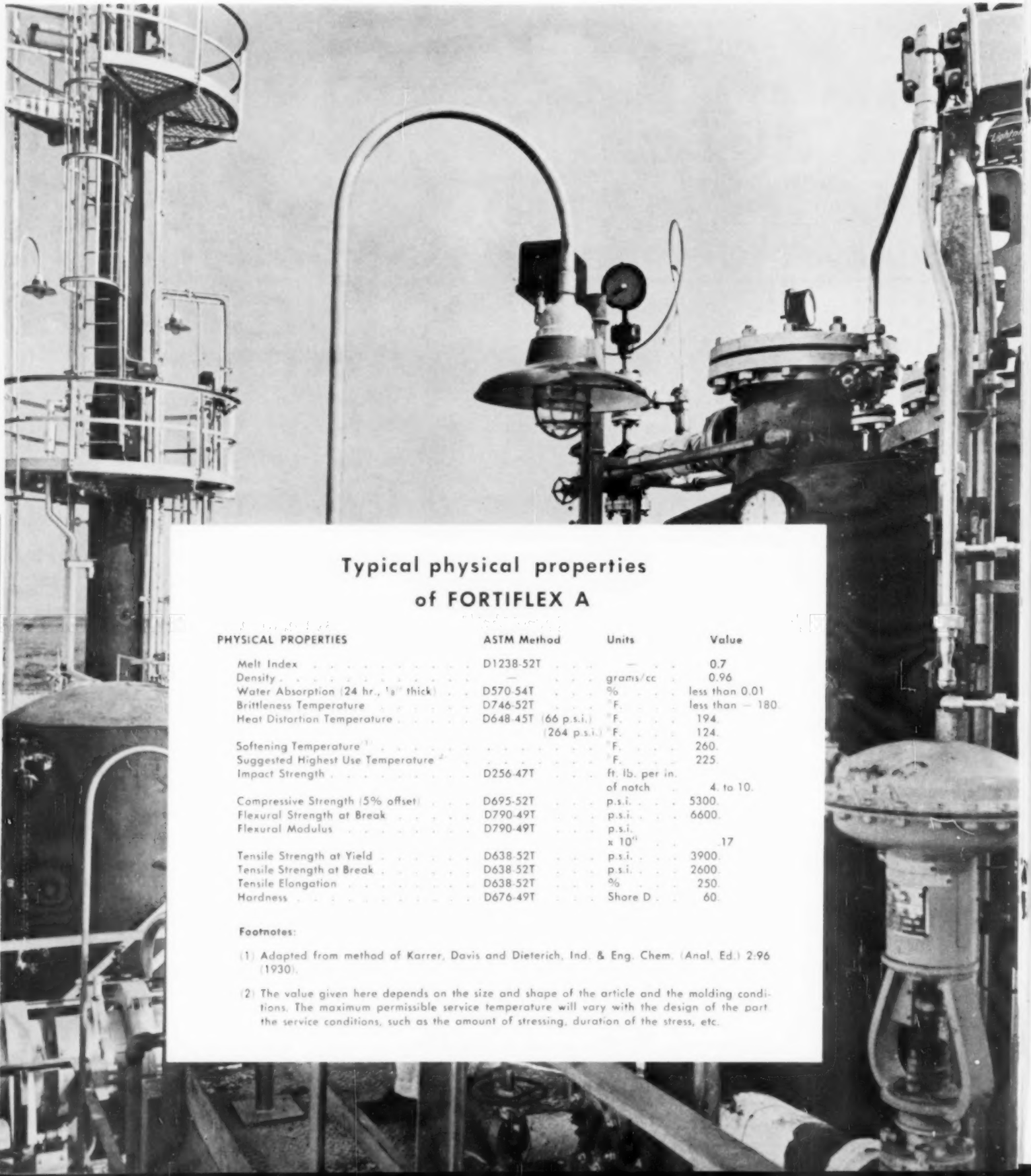


forward step in plastics for development of polyethylene

A new plant to produce FORTIFLEX

40,000,000 lb. annual capacity



Typical physical properties of FORTIFLEX A

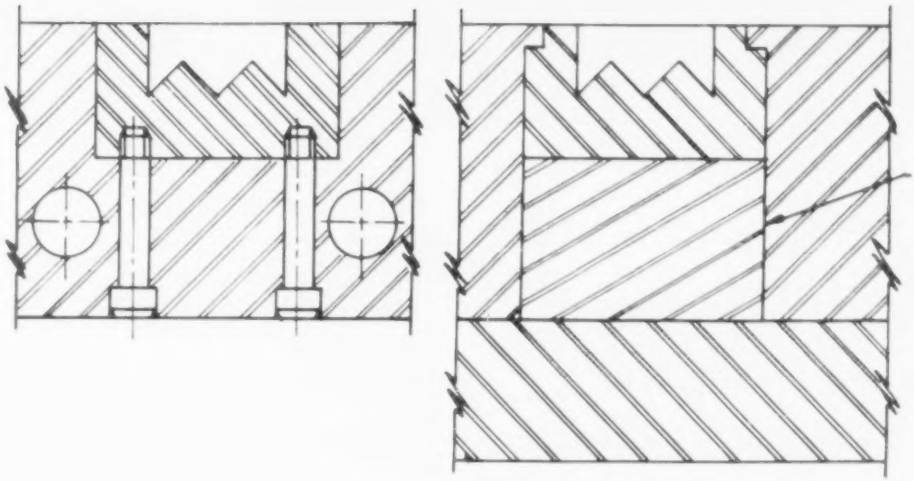
PHYSICAL PROPERTIES	ASTM Method	Units	Value
Melt Index	D1238-52T	—	0.7
Density	—	grams/cc	0.96
Water Absorption (24 hr., 1/8" thick)	D570-54T	%	less than 0.01
Brittleness Temperature	D746-52T	°F.	less than — 180.
Heat Distortion Temperature	D648-45T (66 p.s.i.)	°F.	194.
	(264 p.s.i.)	°F.	124.
Softening Temperature [1]		°F.	260.
Suggested Highest Use Temperature [2]		°F.	225.
Impact Strength	D256-47T	ft. lb. per in. of notch	4. to 10.
Compressive Strength (5% offset)	D695-52T	p.s.i.	5300.
Flexural Strength at Break	D790-49T	p.s.i.	6600.
Flexural Modulus	D790-49T	p.s.i. x 10^{-5}	.17
Tensile Strength at Yield	D638-52T	p.s.i.	3900.
Tensile Strength at Break	D638-52T	p.s.i.	2600.
Tensile Elongation	D638-52T	%	250.
Hardness	D676-49T	Shore D	60.

Footnotes:

(1) Adapted from method of Karrer, Davis and Dieterich, Ind. & Eng. Chem. (Anal. Ed.) 2:96 (1930).

(2) The value given here depends on the size and shape of the article and the molding conditions. The maximum permissible service temperature will vary with the design of the part the service conditions, such as the amount of stressing, duration of the stress, etc.

Figure 4. (right) Modified construction methods for retaining electroformed cavities for small irregular shapes. Pocket construction is shown at left, and high shoulder - construction at right.



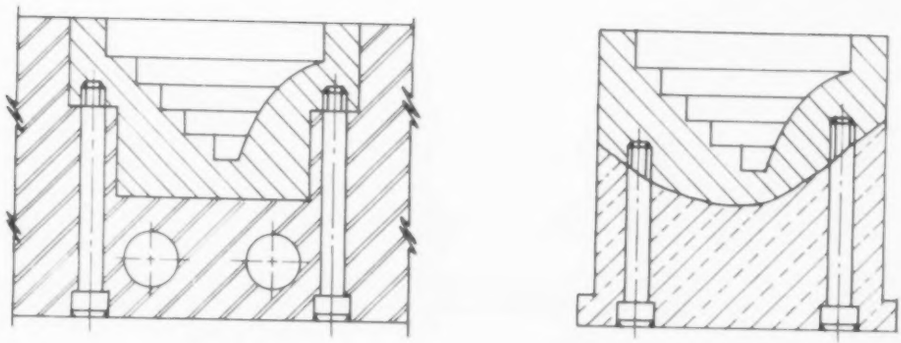


Figure 5. (left) Construction for retaining electroformed cavities of large irregular-shape. Pocket type is shown at right, conventional shoulder type at left.

careful pattern work we can get a bronze casting that will require remarkably little fitting to the electroform.

In designing electroformed cavities for use with thermosetting materials, we must avoid having nickel in the vertical walls of the loading space area. Generally a cavity for these materials consists of hardened steel shell into which is fitted an electroform in such a manner that the softer outer layers of the electroform are not exposed to high pressures. Figure 5 shows a typical construction of an electroformed shell set into a steel sleeve for use in compression molding of thermosetting material.

The electroforming process permits unique cavity constructions for plastic parts of unique design. These parts present some novel solutions in molding and mold design.

Many times molders or designers are faced with the problem of putting a lot of cavities for a small part into a limited area. Hobbing may often appear to be a logical method of forming the cavity. However, in hobbing, only one cavity can be put into a single piece. If many individual cavities are to be produced economically they must be round, and when round cavities are mounted together they take up a lot of space. The amount of distance between the cavities can usually be reduced by making the cavities square. This is expensive. The answer to both problems often lies in electroforming. As an example, assume we start with a single original master for a multiple cavity mold. Through any of a number of techniques we can reproduce this master as many times as desired. We take these multiple casts or moldings and mount them on a single block, spacing them as desired. We electroform against this block and the result is a single electroformed piece incorporating the desired number of cavities. In such construction the wall thickness between cavities generally need only be as wide as the thickness required for the sidewall alone of individual cavities. On most of these small cavities in hobbing or casting, the major item of expense is not the forming of the cavity itself but the finishing off of the cavity. When electroforming a great many cavities in a single block, we have only to finish a single block, and in doing so have finished off many cavities at once. At the present state of the art of electroforming, there is one minor limitation regarding such multiple cavity blocks. The distance between cavities must, for square cavity cross sections, be not less than cavity depth. This construction has been used for both compression and injection molds. Pairs of cavity blocks with matched upper and lower cavity halves can be produced.

Sidewall draft has always been considered a must for the successful molding of plastic parts. The necessity for such draft has frequently meant either the part was not economical to produce by molding, or that it would have to be machined after molding to eliminate the draft, thus adding cost to the piece. Furthermore, cavities having a very high ratio of depth to width are often difficult to produce because of the delicacy of the hobbing operations and the difficulty of final polishing. With electroforming there is hardly any practical limit to the ratio of width to depth. Furthermore, such cavities can be produced (and have been very successfully produced) to mold pieces with zero draft. Here the excellent release characteristics of the nickel molding surfaces, and the fact that the cavity surface of the nicoform exactly duplicates the surface of the master, are the keys to success. The master is carefully polished, all polishing motions being held to the longitudinal.

(Please turn to Page 61)

The Molding of . . .

THICK Polyester Laminates

. . . internal delamination of thick glass-polyester laminates results from a too-short molding cycle and from too-high internal temperatures. Quantitative studies of these factors lead to recommended molding procedures to produce void-free thick laminates . . .

Finn Claudi-Magnussen
Hooker Electrochemical Co.

As a supplier of fire-resistant polyester resins that are used for molding of flat electrical boards, we have often been requested by fabricators to help them produce electrically sound glass mat-reinforced panels by the matched metal die molding technique. What is of particular importance for this application is that each panel be "void-free," that is, free of either dispersed porosity or more extended delamination, and this problem appears to become acute at panel thicknesses around $\frac{3}{8}$" and above.

In 1955, we decided to undertake a study of some of the factors inherent in the molding of such thick panels. The investigations were primarily aimed at the factor that we consider to be the most important source of delamination problems, the exotherm in the interior of the panels. It is our hope that this presentation of some of our results will throw some more light on matched die molding of thick glass-reinforced polyester laminates and will be useful for arriving at resin formulations and molding conditions which will give laminates free of internal delamination.

Analysis of the Problem

When analyzing the problems inherent in the molding of thick laminates (as compared to panels of the more common thicknesses around 1/10"-$\frac{1}{8}$"), it becomes apparent that the following factors are characteristic:

First of all, since longer time is required to heat a greater mass of laminate, longer molding cycles are required to obtain fully cured panels. We felt this problem of longer molding cycles was secondary to the main objective of molding void-free panels.

Second, because of greater mass of polymerizing resin in a thick laminate, higher exotherm temperatures will be obtained in the interior of the panel. Possible causes of bubble formation or delamination such as boiling of monomer or water (the latter introduced with fillers or glass reinforcements stored at high humidity), or the presence of air (entrapped or dissolved in the cold resin mix) would be aggravated by high temperatures. In the experiments described, delamination was indeed always found in the center plane of the laminates where the highest temperatures were reached. Since a shrinkage perpendicular to lamination takes place during the cure, there is room for such delamination to occur in the closed mold operated to stops, and greater wall thickness was observed in areas of the panels which contained internal delamination.

Another factor characteristic of thick laminates is that the problems of complete fill-out and squeezing out of entrapped air are aggravated. Although this might be very important in a molding shop and might explain the occurrence of surface blisters sometimes found, we felt that these problems could not be satisfactorily duplicated in the 12" x 12" laboratory press available for this study.

Finally, a larger stack of glass mat must be cut for each panel. This may be difficult to achieve by one cutting operation in the press and pre-cutting some of the plies might be necessary. However, this was considered mainly a production problem which is not too suitable for solution by laboratory experiments.

Experimental Procedures

The polymerization exotherm was selected as the most suitable object of our investigations. This property was measured in glass mat laminates, about 35% glass, of thicknesses from $\frac{1}{4}$" to 1", either using clear resin or the following formulation which is typical for molding electrical parts:

Mix 1: Hetron 92 diluted with 7½% styrene— 70 parts by wt.
Clay filler —25 parts by wt.
Antimony oxide — 5 parts by wt.

Molding of laminates for exotherm studies was done on open press by enclosing 6" x 6" lay-up in a cellophane envelope and molding to stops between the platens of an 80-ton "Lawtomatic" press, using a final closing speed of around 5 inches per minute. The platen temperature was checked with a surface pyrometer and thermocouples were inserted between the plies of glass mat of the lay-up, the tip of each thermocouple being located at the center of the 6" square. The exotherm curves were plotted by a "Speedomax" recorder.

Matched metal die molding of 12" x 12" panels up to 7/16" thickness (which was the heaviest set of dies available) for the purpose of checking for voids and delamination was done on a 15-tons "Eemco" press, using a final closing speed of around 10 inches per minute.

In our program, we checked the panels for voids and delamination by cutting into strips, sanding the cut surfaces, and—if necessary—painting with "Spot-check" dye, followed by careful visual inspection. Experience with commercially molded panels that were tested with an Ultra-Sonic Void Detector and subsequently sliced and inspected visually has shown that excellent qualitative correlation exists between the destructive and the non-destructive test methods. In areas of a panel that failed by the ultra-sonic test, severe porosity or delamination could always be detected by the destructive method of inspection.

Experimental Results

Exotherm Studies

The results that were obtained from the exotherm measurements are presented in a series of graphs.

Figure 1 represents typical time - temperature curves measured at two levels in a ½" laminate. It is noted that the temperature rise in the interior of the panel lags behind the surface. At about five minutes, however, a sharp rise of the temperature at the center occurs and it reaches a maximum far above that obtained near the laminate surface.

FIGURE 1
STUDY OF EXOTHERM IN LAMINATES

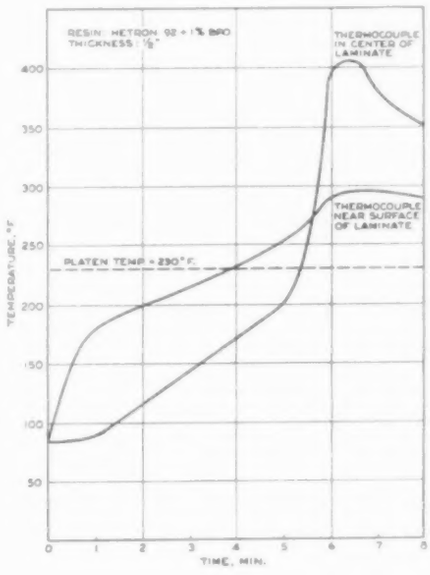


FIGURE 2
PEAK EXOTHERM IN LAMINATES VS. LAMINATE THICKNESS
THE EFFECT OF BPO CONCENTRATION

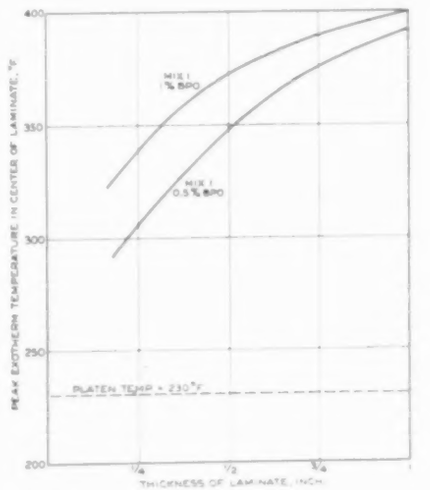


Figure 2 shows how the peak exotherm in the center of laminates increases with the laminate's thickness. Curves are plotted for two levels of catalyst concentration, and it is demonstrated how higher peroxide content results in higher exotherms.

Figure 3 demonstrates how increasing laminate thickness increases the time to reach peak exotherm temperature in center of the panels. Higher catalyst concentration, of course, speeds up the curing process and results in shorter time to reach peak exotherm temperature. Thus, the higher exotherms found with higher peroxide concentration are the result of the combined effects of the exothermic polymerization reaction taking place in a shorter period of time and the increased exothermic heat of catalyst decomposition.

FIGURE 3
TIME TO REACH PEAK EXOTHERM VS. LAMINATE THICKNESS
THE EFFECT OF BPO CONCENTRATION

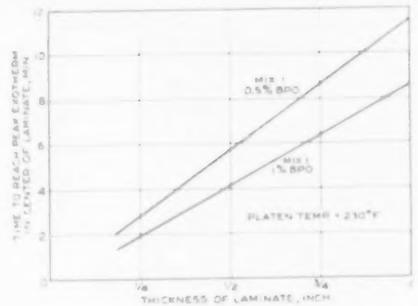


FIGURE 4
THE EFFECT OF BPO CONCENTRATION ON
PEAK EXOTHERM OF ⅛" LAMINATES

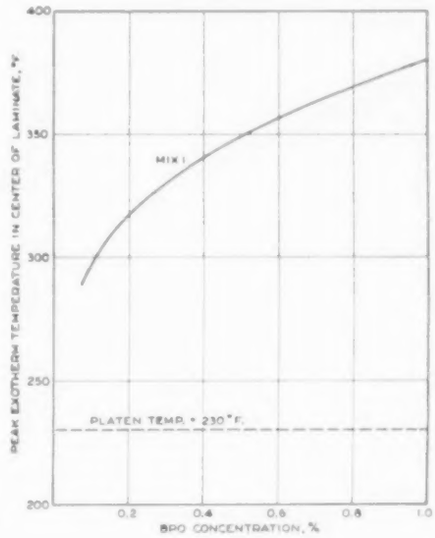


Figure 4 shows clearly how the peak exotherm temperature increases with increasing catalyst concentration, while

Figure 5 illustrates the effect of increasing peroxide content on the time to reach peak exotherm.

FIGURE 5
THE EFFECT OF BPO CONCENTRATION ON TIME
TO REACH PEAK EXOTHERM IN ⅛" LAMINATES

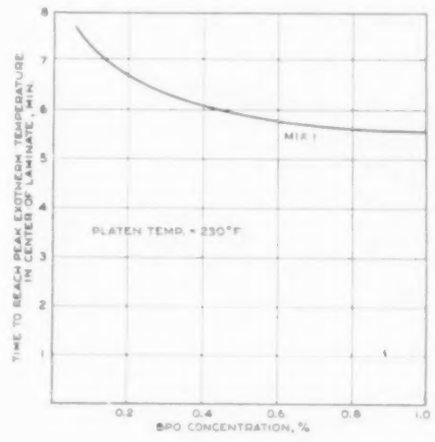


Figure 6 shows the very drastic increase in peak exotherm temperature with increase in platen temperature.

FIGURE 6
THE EFFECT OF PLATEN TEMPERATURE ON PEAK EXOTHERM OF 1/8" LAMINATES

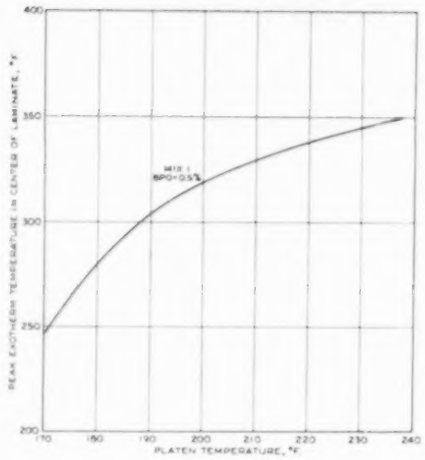


Figure 7 demonstrates the corresponding relationship between platen temperature and time to reach peak exotherm.

FIGURE 7
THE EFFECT OF PLATEN TEMPERATURE ON TIME TO REACH PEAK EXOTHERM IN 1/8" LAMINATES

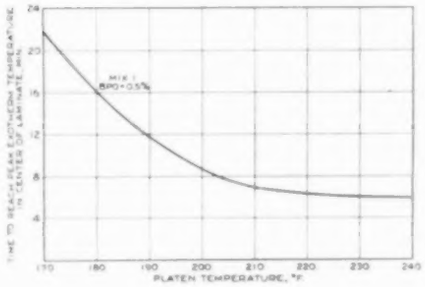


Figure 8 shows how the peak exotherm decreases with increasing filler content, corresponding to decreasing proportion of polymerizable material in the mix. Styrene dilution (at constant filler content) up to 20% did not influence these data significantly.

FIGURE 8
THE EFFECT OF FILLER CONTENT ON PEAK EXOTHERM OF 1/8" LAMINATES

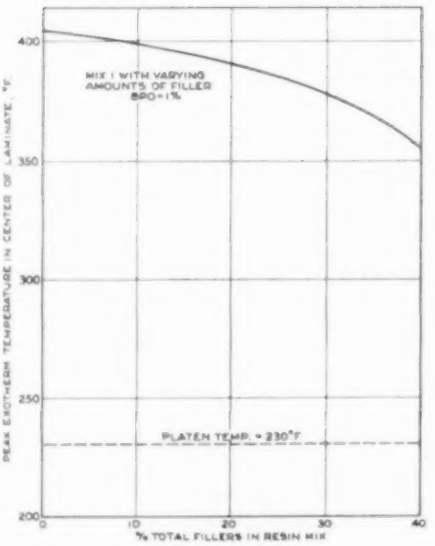
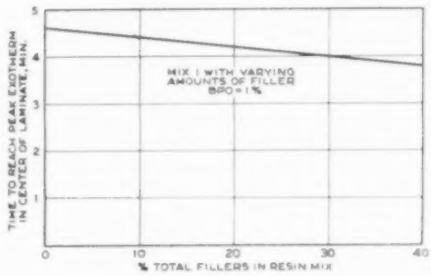

PEAK EXOTHERM TEMPERATURE IN CENTER OF LAMINATE, °F
% TOTAL FILLERS IN RESIN MIX
MIX I WITH VARYING AMOUNTS OF FILLER
BPO=1%
PLATEN TEMP. = 230°F

Figure 9 shows a faster curve with increasing filler proportion, but it is felt that this effect is specific for the filler system used and might not necessarily be typical for all fillers.

FIGURE 9
THE EFFECT OF FILLER CONTENT ON TIME TO REACH PEAK EXOTHERM IN 1/8" LAMINATE


TIME TO REACH PEAK EXOTHERM IN CENTER OF LAMINATE, MIN.
% TOTAL FILLERS IN RESIN MIX
MIX I WITH VARYING AMOUNTS OF FILLER
BPO=1%

The final two graphs show the effects of the use of additives that are known to lower the peak exotherm. **Figure 10** shows a drastic lowering of the peak exotherms from the use of 0.5% of a chain transfer agent, lauryl mercaptan, which incidentally also acts as an accelerator. **Figure 11** shows the effects of various proportions of a chain stopper, alpha - methyl styrene, which also acts as a co - monomer. While both these additives are highly effective in lowering the peak exotherms, they must be used with caution since they do produce lower molecular weight polymers which may impair the final properties of the laminates.

FIGURE 10
PEAK EXOTHERM IN LAMINATES VS. LAMINATE THICKNESS
THE EFFECT OF LAURYL MERCAPTAN

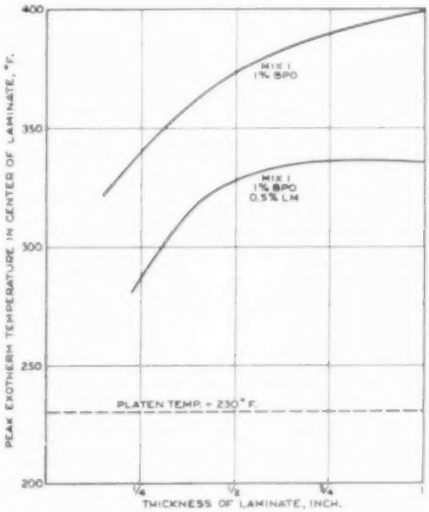
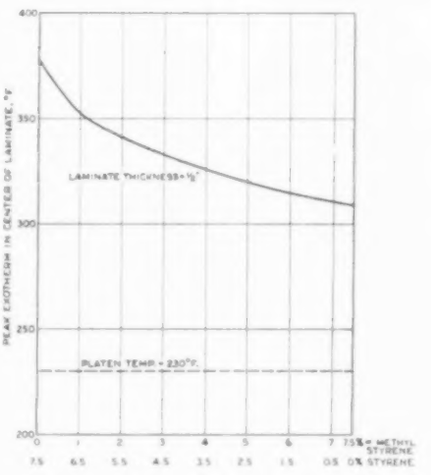


FIGURE 11
THE EFFECT OF VARIOUS AMOUNTS OF α-METHYLSTYRENE ON PEAK EXOTHERM



(Please turn to Page 60)

MOLDING CYCLES

Edited by Louis Paggi, *E. I. du Pont de Nemours & Co., Inc.*

Controlling the Molding Operation

Louis Paggi

Injection molding machines are equipped with pyrometers, pressure gauges and timers which are always used to control the operation.

These instruments are indispensable, and while they can be accurate indicators, they do not always disclose hidden troubles which can develop in the equipment. For example, if one of several heater bands controlled by a single pyrometer should burn out or develop a short, the other bands in the same zone will work harder to maintain the proper temperature at the thermocouple. Since the pyrometer will continue to indicate the same temperature, the trouble which had developed will not be apparent until a periodic check of the heater bands is made.

Temperature Profile

In the meantime, the temperature profile of the heating cylinder will have changed and the molding operation will no longer be under control. As a result, quality will suffer by the sudden development of short shots, flashing, or change in dimensions.

Fortunately, the over-all control of the operation can be checked by timing the stroke of the ram as it pushes material into the mold. This is called "ram-in-motion time." It will indicate accurately a change from normal in the performance of the machine. If the equipment is operating as designed and set up, the ram-in-motion time will change or become erratic.

Mold Condition

Most molders have experienced difficulty in operating a mold under conditions established during a previous run. Discounting a change in material, this is a fairly good indication that the equipment has developed a defect which the usual check of instruments will not disclose. In this case, data on ram-in-motion time taken during the previous run can be used to re-establish the necessary conditions.

The ram-in-motion time may be defined as the time required for the injection ram to travel its full stroke during the filling of the mold. This may be measured very simply by a stop watch, clocking from the moment the ram moves forward to the point where it stops or slows down appreciably very near the end of the stroke. The elapsed time will be equal to the ram-in-motion time. After the mold is filled, the ram slows noticeably while "packing" of the mold and cylinder. This segment should be excluded from the measurement.

Short Ram-Times

For very short ram-times a more accurate method should be employed. This may consist of starting and stopping the watch by means of trip levers or by a combination of limit switches and solenoids. In such an installation, the watch may be placed in a suitable holder during the check of only one or more cycles, then removed to prevent damage to the delicate mechanism by the vibration of the machine. A re-check every four hours should suffice to show if the operation remains under control. The time measured during these checks should be entered on an operation sheet along with other variables. These include such things as temperature, pressure, or material cushion, all measured at the same time.

Trouble Shooting Guide

The following guide shows how observed changes in ram-in-motion time can be used to locate some typical problems arising in molding operations.

1. A considerable change in time occurring between any two cycles is an indication that the trouble is in the hydraulic system. Look for defective check valves or pressure control valves.
2. A change in time occurring shortly after recharging the hopper. Look for a change in material formulation or defective drying equipment.
3. A cyclic change in time occurring over a definite time cycle. Look for a defective pyrometer. A common cause is dirty or worn jewel bearings on the indicating needle. A check for this trouble is to tap the face of the instrument lightly with the hand. If the indicating needle moves more than five degrees in either direction, the instrument should be repaired.
4. A considerable increase in time followed by a series of constant times. This pattern may indicate a defective heater band.
5. Erratic time can be due to many causes among which are:
   a. Non-uniform feeding of material.
   b. Poor thermocouple contact or defective thermocouple.
   c. Defective timers.
   d. Non-uniform delays between cycles.
   e. Non-uniform granulation of material.

It is quite obvious that the ram-in-motion time will not be the same, as molds, machines, or material are changed, but once established for any given job, it should remain constant within very narrow limits.

With pride and pleasure, the SPE Journal introduces the new regular feature Molding Cycles, devoted to the problems of the injection molder. Molding Cycles editor Louis Paggi is well-known in the industry and a foremost authority on injection molding.

Readers are invited to submit articles, suggestions of topics to be discussed, comments on articles or ideas expressed in this column. We respectfully solicit your contributions to the discussion of injection molding problems. Address Louis Paggi, Polychemicals Div., E. I. duPont deNemours & Co., Inc., Wilmington 98, Delaware.

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Extrusion Highlights at the 13th National SPE Conference

Robert D. Sackett

The topic of extrusion received considerable attention at the recent National SPE Conference, with eight papers dealing directly with extrusion techniques and new extrusion materials. In addition three papers were given, which were of indirect importance to extrusion.

Valved Extrusion

Papers were delivered by both Ernest Bernhardt of duPont and by Bruce Maddock of Bakelite which dealt with the use of valves in extrusion. Maddock said that "it was felt that the contribution of the extruder itself toward product quality has not been thoroughly explored or understood." He goes on to point out the effect of various extrusion variables on output and quality and the dependence of one on the other. Maddock suggests that by inserting a valve between the extruder and die, quality can be controlled by maintaining a predetermined back pressure on the screw. Once establishing a pressure-quality relationship for a given screw, material, and application simple adjustment of the valve will maintain the established quality level regardless of the die. Loss in output with high back pressure can be compensated by increasing screw speed. Maddock visualizes the adaptation of pressure control principles to further the automation of extrusion processes.

Bernhardt has approached valved extrusion from a somewhat different standpoint. He has shown how an extruder can be kept running continuously and by interrupting the flow, by means of a properly designed valve, the extruder can be used to eject precise units of plasticized material. The output of an extruder operating under interrupted conditions can actually be run so that the momentary flow rate during the period the valve is open may be considerably higher than the melting capacity of the feed zone. This is dependent on the fact that the shot does not exhaust the amount of melt available in the metering section.

The practical application of this technique is not yet fully realized and Bernhardt plans additional work in evaluating this technique. He feels that the interrupted extrusion operation for producing uniform shots of molten polymer in rapid series combined with simple forming operations can be used to advantage in solving a variety of plastics processing problems.

The technique offers a challenge to the ingenuity of the extrusion industry in finding new applications for extrusion equipment.

Bernhardt further deals with the design of suitable valves and both he and Maddock indicated that existing commercial valves were not satisfactory. The use of valves to control the flow of plastics through multiple orifice dies has also been investigated by Bernhardt and shows considerable promise.

Screw Properties

Robert Colwell of Monsanto has elaborated on previously published extrusion theory to give a more convenient means for computing screw characteristics where approximate adiabatic conditions are involved. A step wise procedure to be followed in the design of a melt extrusion screw when the final temperature of the melt is required is presented. Colwell has shown a series of screw characteristic curves for the adiabatic case and has shown the similarity between the isothermal and the adiabatic conditions. Colwell acknowledged the design of extruder screws based on theory was a tedious mathematical approach because of the interdependence of the many variables. He further stated that ultimate design must be based on practical knowledge of extrusion. Nevertheless the valve of the mathematical approach to indicate the proper direction for initial prototypes must not be under estimated.

Nylon Extrusion

Karel Toll of dul'ont and Robert Hughes of Spencer both had papers dealing with the extrusion of nylon. Earlier nylon extrusion grade compounds had the disadvantage of a sharp melting point and low viscosity. Profile extrusion with these compounds presented considerable difficulties and limited markets.

In discussing duPont's new Zytel 42 extrusion grade nylon, Toll said, that it was 6 times as viscous as molding grade nylon and was well into the melt viscosity range of polyethylene. Because of the importance of melt strength in an extrusion material this new resin fills the requirements of a true extrusion plastic. Zytel 42 is chemically the same as earlier Zytel resins and has essentially the same properties. Toll has discussed the techniques of extrusion as applied to this new resin and predicts that the utilization of nylon extrusion has just begun to be exploited in the areas where toughness, abrasion resistance, and high temperature properties are required.

Nylon 6

Hughes discussed the relatively new nylon 6 type of resin and stated that by changing conditions of polymerization, the melt viscosity of the polymer could be varied within limits. There appeared to be no special problems involved in the extrusion of this new material. Hughes suggested either the use of the standard duPont nylon screw or the standard metering type screw that is more familiar in Europe. This new polymer is satisfactory for use in pipe, blown film, flat film, and sheet extrusion. Blown films one mil and under exhibit good clarity and flat film even up to 5 or 6 mil has exceptional clarity. Hughes said that although nylon 6 is still a relatively high priced compound, its excellent properties should open many new markets in pipe and film applications.

Copolymer Pipe

R. K. Multer of Marbon Chemical discussed the properties of Cycolac (acrylonitrile — butadiene — styrene polymer) with respect to its use in pipe. He discussed the various physical and chemical properties of the ABS materials and pointed up some of the differences between Cycolac and mechanical blends of the same basic chemicals. Multer warned that to obtain optimum properties extrusion must be carried out in accordance with the supplier's recom-

mended procedures without allowing overheating or degradation. He pointed out that this presents no problems as excellent flow properties are obtained at temperatures well below the degradation point.

Screw Design

The importance of proper screw design in the financial success of an extrusion operation was emphasized by Robert Sackett of Monsanto. He discussed the practical extrusion knowhow that can be derived from existing theoretical work. Sackett stated that the advantages of vented extrusion have not been fully developed but that the technique went considerably beyond merely replacing a hopper dryer. The importance of proper screw design in vented extruders in overcoming balancing problems was pointed out. Sackett further cautioned the indiscriminate use of the term compression ratio and stated that it was the way that the compression ratio was obtained rather than the compression ratio itself that was important.

Blow-up Ratio

Charles Kucher of Spencer stressed the importance of blow-up ratio in blown-film extrusion of polyethylene, in obtaining optimum strength properties. He suggested that whenever feasible blow-up ratios in the neighborhood of 3-1 to 4-1 should be used to give the best combination of tensile, elongation and impact properties. The data presented was run at full take-off speed and no investigation was made of the effect of different take-off rates, temperature, etc. Kucher realized that it was not possible to stock a wide range of dies or to be constantly changing dies to fit a rapidly changing order pattern in order to maintain optimum blow-up ratios. He pointed out that a serious effort should be made to use optimum blow-up ratios however.

Temperature Control

In discussing the problem of temperature control in injection molding machines and extruders, R. K. West of West Instrument Corp. stated that there is no proper single depth for a thermo couple to answer all conditions of operations to the maximum advantage of the machine user. The use of dual parallel thermo couples—one mounted near heating bands and one located deep in the barrel wall—give more uniform control on the plastic temperature. Proportioning type instruments used with single thermocouples reduces cycling; however the fundamental reasons for the wide variation is that the heat input requires time to penetrate the steel wall and reach the thermocouple tip, and even though the instrument may turn off, there is still a large heat capacity stored within the wall passing from the heater to the thermocouple. West advocates the use of dual thermocouples as a relatively inexpensive means of improving existing temperature control in both injection molding and extrusion equipment.

Research Debate

An interesting highlight of the conference occurred in the Research symposium, where diametrically opposed views were presented by two of the speakers. The following is the way that Murray Underwood of Monsanto analyzed these two papers.

"It is a common experience among extruders that for a given die and operating temperature, there is a rate beyond which one cannot go without running into a surface roughness problem. This happens in extruding sheet, film, wire coatings, pipe, and profiles. The question is: Is it possible to change die designs or operating conditions so that higher rates can be obtained without getting into this critical roughness range? If so, how does one go about it? John Tordella of duPont elaborated on his previous paper on melt fracture and showed a movie of a plastic melt flowing through a glass die. Tordella's opinion is that the roughness results from stresses which are so large, and so quickly applied, that the structure of the melt is broken. R. F. Westover of Bell Laboratories, on the other hand, believes that the roughness is a turbulence effect which is related to some critical value of the Reynolds number.

Flow Roughness

"According to Tordella's theory, the roughness will start to occur at same constant value which is proportional to the flow rate divided by the cube of the radius of the opening, and will be strongly affected by the internal shape of the die just before the opening. Westover's interpretation is that the point at which roughness occurs will depend upon the rate of flow divided by the radius to the first power, affected by such factors as the surface roughness of the die lands.

"This is not the place to express an opinion as to the correctness of either theory. We do wish to point out, however, that such differences of opinion can be extremely valuable. They will undoubtedly challenge a number of people to make tests of their own, and the results of these tests will be of great help in our understanding of die design.

"It might be well to make it a point that the differences in opinion between Tordella and Westover were on the mechanism by which the roughness occurs. They did not disagree on the fact that such roughness does develop at critical conditions."

Figure 1. Molten ethylene extruded through glass orifice. Black specks make flow pattern visible.

The moving picture that Tordella has filmed is something that should be seen by all in the extrusion industry. The flow patterns that occurred inside the glass die used are almost unbelievable. Figure 1 is a photograph of the glass dies used and the flow pattern is made visible by a mixture of black polyethylene mixed with natural resin.

International Symposium On Synthetic Rubber

A symposium on synthetic rubber will be held March 26, 27, 28 at Church House, Westminster, London, England. The program is listed below. For further information contact Rubber and Plastics Age, Gaywood House, Great Peter St., London.

Ameripol SN Rubber
R. P. Kenney

Auxiliary Materials for Synthetic Rubber
W. McG. Morgan

British Developments in Synthetic Rubber
E. A. Murphy

Butadiene-Vinyl Pyridine Copolymers
W. Gumlich

Butyl: Part I—General
W. C. Smith, W. L. Dunkler, R. L. Zapp

Part II—Butyl Rubber Tyres
D. J. Buckley

Effect Cis-Trans Ratio on the Physical Properties of 1,4—Polybutadienes
J. N. Short, Vernon Thorton, Gerard Kraus

German Synthetic Rubber Developments
Paul Baumann

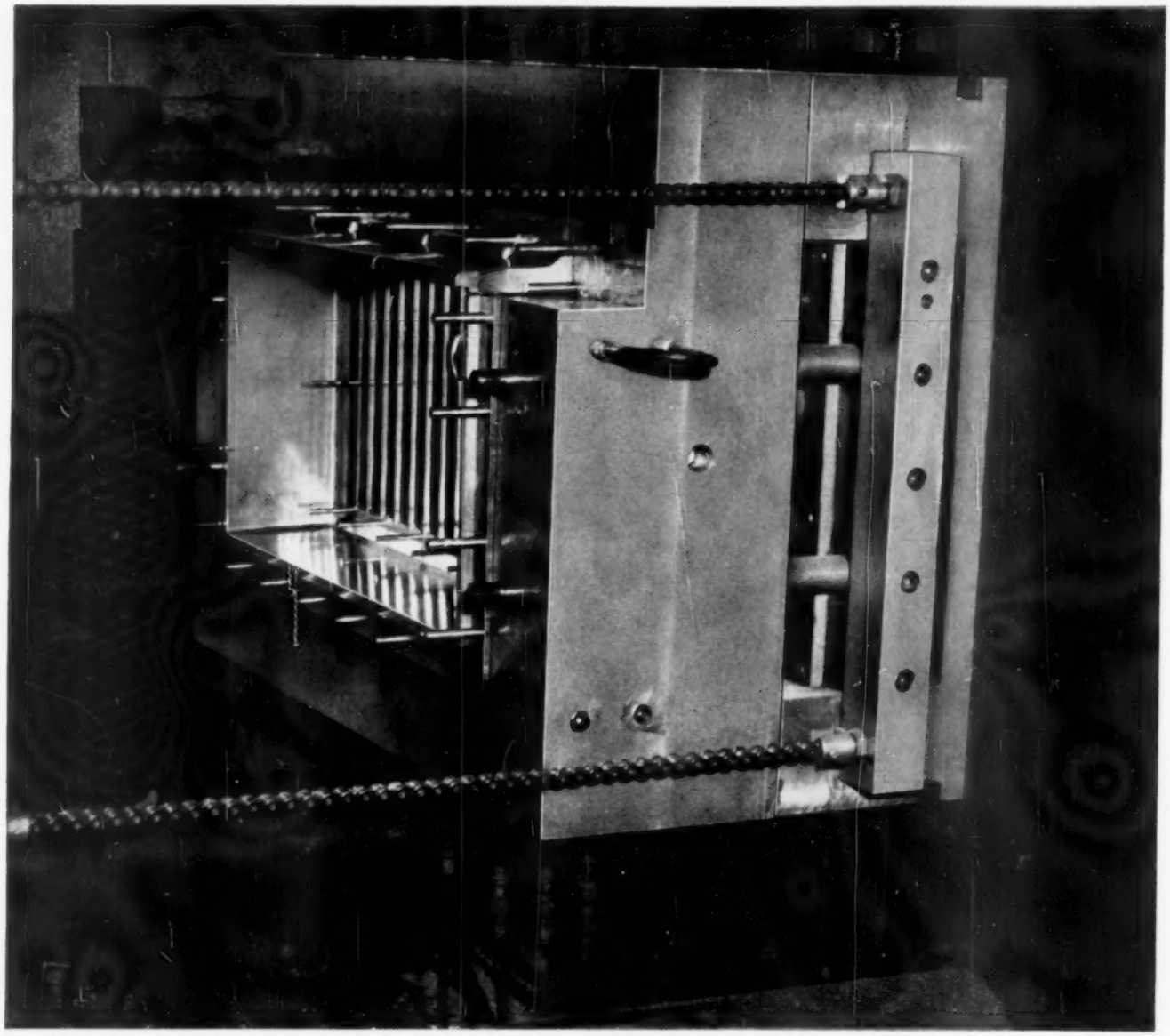
Neoprene Latices
E. P. Hartsfield

Nitrile and other Acrylic Rubbers
S. Mottram & P. H. Starmer

Organic Fluorine Rubbers
J. C. Tatlow

Self-Reinforcing Elastomers

Silicone Rubber — Its Growth and Recent Developments
Philip C. Servais, and Dr. I. H. Riley



CRUCIBLE CSM 2 mold in press at Pro-phy-lac-tic Brush Co., Florence, Mass. The mold, built by Eagle Tool & Machine Co., Hillside, New Jersey, produces vegetable pans for Hotpoint refrigerators.

why **CRUCIBLE CSM 2**

is chosen for so many big molds . . .

One reason is that CRUCIBLE CSM 2 is always uniform in structure and composition. It's got to be. For the quality of every *heat* is controlled by Quantometer analysis . . . and every *piece*, regardless of size, is ultrasonically inspected. This means superior machining and polishing characteristics.

Another reason is that CRUCIBLE CSM 2 is immediately available from *warehouse* stock in 205 sizes, big and small. The job isn't held up for steel when you order CSM 2, the mold steel you can *trust* and get *when* you want it. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

THE TECHNICAL LEADERSHIP of the Society of Plastics Engineers was self-evident in the excellent 13th annual conference recently concluded in St. Louis. The quality of the papers presented on a broad range of subjects was high. Lecture rooms were crowded to capacity. Questioning was brisk and constructive. They were indicative of a sincere desire to learn.

An examination of the program shows nearly 60% of the papers were presented by men affiliated with plastic material suppliers. This fact allows room for criticism since our society is an organization of individual engineers from all branches of the industry. We need more universal participation in technical activities to serve the interests of all members better and to provide recognition for scientific and practical advances made by the "silent segments" of the industry.

It isn't difficult to write a good paper. It may be just as difficult to write a poor one. Presentation of a well-executed paper offers advancement in professional reputation of the author. His employer will realize this. What boss can resist boasting to his associates: "I have a boy from my engineering department giving a paper at the SPE national meeting in Detroit in January"? Or telling his customers, "Of course, our engineering department is highly rated. Several of our men have given talks at the SPE annual technical meetings and they are well respected in the industry." Or resist handing a prospective customer a reprint of the technical paper to prove the solid quality of his organization? This is not speculation—it happens in the plastic material supply business all the time.

Some folks like to keep their discoveries and developments secret. Patents and trade secrets have helped American industry tremendously. Trade secrets have a way of becoming common knowledge very quickly. But often it is a good idea to receive credit for a discovery before it has been kicked around so much no one can recognize it.

It is a well-known fact our own ideas often can be augmented by discussion with others. Who has not come out of such a session without finding the discussion has improved the ideas he took into it?

One of the greatest advantages an engineer can derive from writing a technical paper is a much better understanding of his own knowledge. Half-baked ideas are quickly seen in their true dimensions and must be discarded when considered coldly for acceptance in print. Half-understood ideas must be reduced to complete and simple statements with the surprising effect of making the author more sure of his conclusions. Unnoticed ideas appear to an author when he sets out to organize his story and then contemplates what he has organized.

All of this sounds very inspiring but human nature was born loaded with the inaction which makes us all rather resistant to inspiration.

JANUARY 1958 IS ONLY A MONTH AWAY, as far as decisions on presenting papers are concerned. Notices will soon be in the mail to all SPE members requesting papers and suggestions for the 1958 meeting. A few of many topics which need discussion are offered to stimulate further thought on the part of SPE members. As a "starter," a few topics are: novel applications of plastics, automation, maintenance, plant layout, materials handling, testing of finished products, and in-plant training of plastics engineers.

The 1958 annual technical conference will be as good as the participation of all SPE members make it. The Speakers Committee will do its part in arranging the mechanics of presentation of the papers if the members of SPE will provide the technological material.

W. C. Goggin

W. C. Goggin
Chairman, Speakers Committee
SPE 1958 Annual Technical Conference

Demonstration of a 4½" Prodex PVP 24 Vented Extruder with 30 degree Prodex cross head. See this machine demonstrated on your own material.

A demonstration proves the superior performance of the Prodex PVP 24 Extruder

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Typical Production Rates of Prodex PVP 24 Extruders

Extruder Size	Drive H.P.	Cross Section	POUNDS PER HOUR		
			PVC Dryblend	Polyethylene Pipe Cpd.	Polystyrene High Impact
2½"	20	.11 sq. in.	180-240	150-180	150-240
4½"	60	.25 sq. in.	550-660	450-520	500-630
8"	200	1.00 sq. in.	1700-2100	1450-1600	1500-1900

No porosity was present in any of the above extrusions. All compounds contained at least 1% moisture and were not extrudable on ordinary machines without porosity. All rates at precision tolerances.

Prodex PVP 24 Extruders are available in 1¾", 2½", 3½", 4½", 6", 8" sizes.

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PRODEX

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MANUFACTURERS OF PROCESS AND EXTRUSION MACHINERY

Plastics Activities of the International Standards Organization

Norman Skow
Synthane Corporation

I.S.O. might be defined as the International A.S.T.M. and TC 61 is the technical committee responsible for the work on plastics I.S.O.

TC 61 held its sixth meeting this past Fall at The Hague and our American delegation reports that the work is beginning to show progress.

Technical Committee 61 on Plastics of the International Organization for Standardization set new records for attendance and accomplishment at The Hague meeting during the week of September 17-22, 1956. Approximately 90 delegates from 15 nations acted on 23 Draft I.S.O. Proposals and Draft I.S.O. Recommendations during the six day meeting. Hungary, Poland, Rumania and the U.S.S.R. were represented for the first time.

The sessions were highlighted by several significant developments. One of these was agreement that the primary purpose of I.S.O. TC61 is to develop test methods for commercial use. A corollary to this is that test methods will be based on existing national standards. A direct result of this policy clarification was the adoption of Draft I.S.O. proposals for impact testing based on U.S. (A.S.T.M.) and German (D.I.N.) standards.

A milestone in TC61 history was passed when five methods were approved for submission to the I.S.O. Council for promulgation as I.S.O. Recommendations. These methods cover the determination of (1) Temperature of deflection under load (heat distortion), (2) Water absorption, (3) Apparent density of molding powders which can be poured from a funnel, (4) Apparent density of molding powders which cannot be poured from a funnel, and (5) Acetone soluble matter of phenolic moldings.

The various working groups are studying Nomenclature and Definitions; Preparation of Test Specimens; Aging, Chemical and Environmental Resistance; Standard Laboratory Atmospheres and Conditions; Mechanical Strength Properties; Physical-Chemical Properties; Thermal Properties and Electrical Properties. The delegates from the various countries have now worked together long enough to respect and trust one another and their cooperative work indicates the development of I.S.O. test methods which will be of direct interest to scientific investigations and the compilation of engineering data.

The American delegation was well qualified in the technology of plastics standardization. Represented in this group were government, trade society and industry, as follows:

C. H. Adams, Monsanto Chemical Company, Leader
W. E. Brown, Dow Chemical Company
R. Burns, National Academy of Sciences
C. L. Condit, Society of the Plastics Industry
G. M. Kline, National Bureau of Standards
M. C. Reed, Bakelite Company
N. A. Skow of Synthane Corporation representing S.P.E.
A. C. Webber, E. I. du Pont Company
P. E. Willard, Ohio-Apex
E. Y. Wolford, Koppers Company

The 1957 meeting will be held in Switzerland probably in July. The U. S. invitation to hold the 1958 meeting in America has been accepted and plans are already under way for this to immediately precede or follow the fall meeting of A.S.T.M. Committee D-20. A symposium on plastics testing in which the foreign delegates will be invited to participate will be scheduled during the week of the D-20 sessions. The greatest burden on our delegation for the 1958 meeting will be to match the generous hospitality of our European friends. All of us will have to lend our aid in this most worthwhile endeavor.

Industrial Literature

Glass Fibers As Reinforcement Of Plastic Laminates

Glass fibers for reinforcement of plastic laminates are studied in three reports by the Armed Forces released for industrial use through the Office of Technical Services, U. S. Department of Commerce.

CHEMICAL FINISHES FOR GLASS FIBER. P. Erickson and I. Silver, Naval Ordnance Laboratory. April 1953. 29 pages. 75 cents. (Order PB 121165 from OTS, U. S. Department of Commerce, Washington 25.) Synthesis of ten finishes with RN-48 and selectron 5003 in glass cloth laminates proved the Bjorksten finish most effective in improving the high strength of resin-glass cloth plastic laminates under dry and wet conditions. Improvements indicate that the strength of the Bjorksten finish can be further advanced.

UNIVERSAL TYPE CHEMICAL FINISHES FOR GLASS FIBERS USED IN REINFORCED PLASTICS. P. Erickson, I. Silver and H. A. Perry, Jr., Naval Ordnance Laboratory. Oct. 1954. 17 pages. 50 cents. (Order PB 121172 from OTS, U. S. Department of Commerce, Washington 25.) Five chlorosilane type finishes for glass fibers used in reinforced plastics were synthesized and evaluated for superior resin glass adhesion. Laminates of 181 glass cloth with NOL 24 finish bonded with phenolic, epoxy and polyester resins exhibited ultimate flexural strengths, dry, ranging from 97,000 to 108,000 psi. NOL 24 was selected for commercial development, according to the report.

FIBER PROJECT. J. Farber, Polytechnic Institute of Brooklyn for Office of Naval Research. May 1955. 40 pages. $1.00. (Order PB 111806 from OTS, U. S. Department of Commerce, Washington 25.) High tenacity in polyamide fibers can be attained by increasing the number of hydrogen bonds per unit length of the chain, experimentation disclosed. Various syntheses of 1,n polyamides are described and the reaction products studied.

1956 SUPPLEMENTS TO BOOK OF ASTM STANDARDS

Part 6. Rubber, Plastics, Electrical Insulating Materials — 380 pages. Includes 71 standards covering plastics; electrical insulating materials; rubber products (processibility tests, interlaboratory tests, synthetic elastomers, physical tests for vulcanized rubber, low temperature tests of rubber, automotive and aeronautical rubber, packing and gasket materials, hose, electrical protective equipment, insulating wire and cable, latex foam sponge and expanded cellular rubber, non-rigid plastics); and electronics materials.

The 1956 Supplements, in heavy paper covers, can be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at $4.00 per part — or $28.00 for the complete set of seven parts.

Polyphosphates

ELASTOMERIC POLYPHOSPHATES, Part 2. R. A. Hubbard II and U. P. Strauss, Rutgers University for Wright Air Development Center. May 1956. 37 pages. $1. (Order PB 121391 from OTS, U. S. Department of Commerce, Washington 25.) Cross-linking of polyphosphate chains was attempted as part of a project to prepare an elastomer whose backbone is the polymetaphosphate chain. Molecular weights of crystallized potassium polyphosphate were shown to be as high as 3×10^6, or sufficient for use in elastomeric materials. A procedure for cross-linking of polyphosphates by fusion is explained. Another is described for the reduction of intermolecular forces by separating the chains as much as possible.

Specifications

A guide to the specification of quality and workmanship in laminated plastic materials procured for military use has been prepared by the Navy and released to industry through the Office of Technical Services, U. S. Department of Commerce.

The report, PB 121277 **Defects of Importance in the Specification of Reinforced Plastic Products,** F. R. Barnet, Naval Ordnance Laboratory, Mar. 1953, may be ordered from OTS, U. S. Department of Commerce, Washington 25. It contains 53 pages, price $1.50.

Processing Case Histories

A new booklet describing plastic processing case-histories has just been published by Fostoria Pressed Steel Corporation, Fostoria, Ohio—pioneer manufacturer of infrared ovens.

The eight-page booklet contains actual capsule case-histories on heating, baking, drying, dehydrating and curing operations in a variety of industries. The booklet may be obtained free of charge from Fostoria Pressed Steel Corp., Fostoria, Ohio. Request Bulletin 56-106.

Men In The News

John Marco

John Marco, well known for his pioneering vision, and inventor of continuous mixers, reactors, copolymerization, foam generators and many other continuous processing, technological and mechanization methods, has resigned the post of president of Marco Company, Inc. to take a new post as President of Marco Development Co., Inc., with offices at 815-825 West 5th Street, Wilmington 1, Delaware.

F. R. Kiernan

Kurz-Kasch, Inc., custom and proprietary plastic molders in Dayton, Ohio, have recently appointed F. R. Kiernan as Vice President in Charge of Manufacturing. Kiernan has been with this pioneer plastic molding concern for slightly over three years in the capacity of Works Manager. He came to Kurz-Kasch from the Monterrey Mexico Subsidiary of the American Metal Co., Ltd. where he was Chief Industrial Engineer.

Cordo Officers

Cordo Chemical corporation of Norwalk, Connecticut, announced today the appointment of the following officers: George H. Sherrard, executive vice president; Grant Brown, vice president-technical director; Robert G. Forsythe, resident vice president, Mobile, Alabama plant. William F. Condon was appointed vice president of Cordo Molding Products, Inc., The Cordo sales affiliate with offices at 230 Park Avenue, New York City.

Hercules Powder

New assignments for three men in the Cellulose Products Department of Hercules Powder Company were announced as: J. B. Martin, who has been supervising plastics promotional activities, is transferred to the company's Export Department to develop export plastics markets. Robert C. Clark, who has been manager of the department's Cincinnati Office, is transferred to Wilmington to aid in plastics sales and promotional work. Gregory N. Bruxelles, at present a member of the sales development staff, is named manager of the department's Cincinnati Office.

AROUND THE WORLD

AUSTRALIA

AUSTRALIAN PLASTICS & RUBBER JOURNAL

Vol. 12, No. 135, Oct. 1956

Abstracter: Albert Lightbody

AUTOMATION AND THE CHEMICAL INDUSTRY—W. B. Clarke.

An abstract of an address given at a symposium at Sydney on "Automation." The advantages of automation, beyond that of cost, are given, such as improved quality control, reduced electrical or steam peak loads, reduced intermediate inventories. Automatic equipment requires a good preventative maintenance control, men with special skills, good market research and developmental research.

CANADA

CANADIAN PLASTICS

December, 1956

Abstracter: Harriman H. Dash

THE VINYL ACETATE FAMILY OF PLASTICS — pp. 36 ff — A staff report on the production of vinyls (acetates, alcohols, and acetals) by Shawinigan Chemicals, Ltd.

Vinyl acetate monomer is produced by passing acetylene and acetic acid at 200°C through charcoal impregnated with catalysts (zinc or cadmium salts). Bulk and emulsion polymerizations are used to produce the various grades of polyvinyl acetate (Gelva). Tables of grades and properties are presented as well as brief descriptions of a number of uses (adhesives, molding compositions, films, coatings, bubble gum, paints, etc.). Polyvinyl alcohol (Gelvatol) is manufactured by the hydrolysis of the acetate polymer. A listing of uses for low-acetate and medium-acetate grades of polyvinyl alcohols is also given. A very useful group of polymers known as the acetals are obtained by reacting PVAlc with various aldehydes—formaldehyde (Formvar), acetaldehyde (Alvar), and butyraldehyde (Butvar). The latter resin has volume use as the bonding interlayer in safety glass. The acetals in general have very good adhesive and electrical properties. This accounts for their wide use in electrical wire coatings. A brief historical sketch of the development of Shawinigan Chemicals is also presented. This traces the growth of the company from its modest beginning in 1861 at Ontario by the inventor of the calcium carbide process, Thomas L. Willson.

The following one to two page articles of general interest only also appear in the December issue:

The use of Styrofoam in Building Construction—49

The New Kason Polystyrene Plant at Preston, Ontario—p. 34

Radiation and Plastics—p. 52.

The Use of Plastics In the Automotive Industry—p. 42

FRANCE

INDUSTRIE des PLASTIQUES MODERNES

December, 1956

Abstracter: Hans Mayer

PLASTIC SHEETING IN AGRICULTURE.

The possible applications of light gauge polyethylene and polyvinyl sheet materials are almost unlimited. Some of these applications and their technical and economical results are described.

TECHNICIANS FOR THE POW PRESSURE REINFORCED PLASTICS INDUSTRY.

With the collaboration of government agencies courses for the training of technicians for this branch of the industry have been set up in facilities at Champs-sur-Marne. Conditions for the admission and a description of the training schedule are described.

LOCKWASHER.

A Dutch development, the "Dubo" nylon lockwasher is described. It is claimed that this lockwasher does not have to be centered and will create a tight lock which cannot be loosened by vibration.

November, 1956

GRAPHITE, NYLON, ALUMINUM — P. Migny.

The effects of additions of .5 to 4% per weight to nylon type molding compounds are described. The design of a bearing containing nylon molded parts for the purpose of permitting closer tolerances in bearings exposed to quick temperature changes is discussed.

ANALYSIS OF UNDERGROUND PLASTIC PIPING SYSTEMS — Michel Delattre.

The use of polyethylene piping for water systems has become attractive due to the ease of getting the lines underground and due to the length of the individual links of the system. However, due to the same reasons dislocations and bends will show up in the system rather frequently. When leaks occur in such piping system, it is very difficult to find the spot of the linebreak from above the ground. A number of methods developed for the purpose of spotting such leaks without removing the pipe from the ground are described.

GERMANY

KUNSTSTOFFE

December, 1956

Abstracter: Anne Schwend

PLASTIFICATION OF PVC — Ottmar Leuchs

An analysis of the structure of plasticizer molecules revealed that they contain both polar and non-polar groups, the ratio of which is of decisive influence on the plasticizer's compatibility with PVC. The polar groups serve adhesion, while non-polar molecules are sub-divided into polarizable (aromatic) and non-polarizable (aliphatic) types, hence two contrasting types of plasticizers. The polar-aliphatic type (f.i. trioctylphosphate) is hard to mix with PVC and lowers the second order transition point of PVC considerably.

Kunststoffe . . . (con't.)

The polar-aromatic type can be mixed well, gelatinizes well and lowers the second order transition point of PVC much less. The former type of plasticizers screens the polar groups of PVC molecules; the latter transmits intermolecular forces in the sense of a multiple jointed hinge. Customary plasticizers usually represent a mixture of these two extremes.

These statements led to new proposals regarding internal plastification of polymers and polymer plasticizers of anti-freezing properties.

SEPARATION OF HYDROCHLORIC ACID FROM CABLE COATING MATERIALS CONTAINING PVC— Bernhard Schmitt and F. Heck.

Description of a method to determine the quantity of hydrochloric acid separated from cable coating compounds containing PVC at temperatures below and beyond the usual processing temperatures. By directing the gaseous decomposition products, formed upon heating of PVC-holding compounds, into conducting water and registering the change in conductivity then taking place, a curve is obtained revealing the decomposition strength of the specimen under consideration. From the quantity of separated hydrochloric acid thus determined the speed of decomposition can be calculated.

This method, though more circumstantial than customary indicator methods due to equipment needed, but superior to all visual methods, may also be used for determining the heat stability of PVC powders, PVC compounds for rigid processing, and soft PVC films at processing temperatures of interest.

PHYSICISTS' CONFERENCE IN MUNICH IN SEPTEMBER 1956, A BRIEF ON PAPERS PRESENTED AT THE CONFERENCE OF SPECIALISTS IN HIGH POLYMERS—H. W. Paffrath.

The dynamic-elastic behavior of Vulkollan, a poly-addition product of diisocyanate with polyester carrying free hydroxyl groups.

G. W. Becker.

The dynamic-elastic behavior of polyamides and polyurethanes as a function of frequency, temperature and water content.

J. Koppelmann:

Method to determine the dynamic modulus of elasticity and the dynamic modulus of shear of high polymers within 10^{-5} to 10^{-1} Hz.

R. Kaiser:

Forming of polyethylene under heat—Investigation of polyethylene films in the ultra-red spectrum showed that the decrease in crystalline structure is lower when forming films under heat influence than upon cold shaping. Tests conducted under polarized light shall give hints as to location and share of crystalline and non-crystalline zones vertical and parallel to the direction of elongation.

F. H. Mueller and A. Engelter:

Method to determine heat effects upon drawing.

T. H. Gast:

Measuring the heat conductivity of plastic films over a wide temperature range.

F. Wuerstlin:

Attempt at a molecular explanation of the external plastification of high molecular materials.

H. Veith:

Dielectric properties of sorption water in plastics.

POLYCARBONATES — A NOVEL THERMOPLASTIC

In search for high-melting polyesters the Uerdingen plant of Farbenfabriken Bayer has developed polycarbonates. Although, in principle possibilities for the production of polyesters from carbon dioxide were known, there was no way of producing high moleculars. Emanating from 4,4'-dioxy-diphenyl alkanes, of which were produced about 30 different types, these alkanes were dissolved in dilute soda lye and phosgene was added at 20 to 30° C. so that solid polycarbonates formed. The molecular weight may be adjusted. Polycarbonate produced so far dissolved in methyl chloride, a number of aromatic hydrocarbons, esters and ketones. In the absence of water, vapor and alkalic or sour impurities, they are stable also over long periods, in molten status up to and about 300° C. Customary production techniques may be used for fibres, films and lacquer coatings from polycarbonate solutions. Fibres, films, blown films and bodies, injection and compression molded articles may be produced from the melt. Concentrated solutions will emulsify in water.

Properties: Melt zone between 150 to 300° C.; low water absorption; very low gas permeability, highly resistant to ageing with no changes in color or physical properties over several years; resistant to water, neutral saltic solutions, watery mineral acids, nitric and hydrofluoric acids, watery solutions of organic acids and strong oxidation means, weak alkalies, aliphatic hydrocarbons, higher alcohols, synthetic and vegetable oils and fats. Polycarbonates are resistant only to a limited degree to strong alkalies, ammonia and amines.

HOSTAPHAN FILM FROM POLY-TEREPHTHALIC ESTER—O. Herrmann.

A license contract between Farbwerke Hoechst and ICI for production of polyethylene terephthalate and subsequent production of Trevira fibres and films form the basis for today's market in Hostaphan films which are available in thicknesses of 20, 25, 33, 40 and 50 u, to which 10 and 15 u, are being added at present. Further extension to greater and lower thickness of films is under consideration.

PVC AGGLOMERATES — George Wick and H. Koenig.

Possibilities and limitations in eliminating the granulation process and molding finished articles directly from the powdery plasticizer-containing-PVC are discussed. Emulsion-type PVC with a maximum of 33% plasticizer can be mixed and gelatinized in a mixer of suitable rotor design and peripheral speed. Purling soft PVC of low granule size is obtained. To obviate caking upon further addition of plasticizer, the agglomerate is cooled down to room temperature in a second mixer and plasticizer of 100 to 150° C. is sprayed into the agglomerate, in practice feasible up to a 45% plasticizer ratio. Production of plasticizer - containing - suspension-type-PVC is much easier and can be accomplished in a mixer permitting both heating and cooling.

A comparison of both PVC granules and agglomerates showed little difference in processing. The advantages that granulated compounds may have over agglomerates may be compensated by insertion of strainer plates, pressure increase in the extruder by nozzle extension or higher worm progressivity.

DETERMINATION OF POTLIFE, CURING AND GEL-TIME OF NON-SATURATED POLYESTERS — H. Schirmer.

Description of a new meter measuring and registering simultaneously both the temperature reaction of polyester after addition of catalyzers and the change in viscosity taking place, working on the principle of an electro - mechanical vibrating reed viscosimeter. Neither the gel-time-test suggested by SPI in 1951 nor General Electric's gel - time - meter could indicate both values during one single test operation. This new meter registers the temperature-time and the viscosity-time curves on the same strip of tape. A uni-directionally free vibrating steel reed, immersed into polyester heated to the temperature at which measuring shall be effected, is excited by an electromagnet, vibration frequency and exciter amplitude being kept constant during tests. With increasing polymerization and, hence, solidification of the polyester, the resonance frequency of the vibrator becomes gradually lower and the resonance curve flatter which entails a decrease in the amplitude of the reed, consequently also a lowering of the registered tension. A second recorder registers the temperature at the same time.

GLASS FIBRE REINFORCED PLASTICS FOR THE BUILDING INDUSTRY—Waldemar Beyer.

A survey on continuous and semi-continuous production methods of

Kunststoffe . . . (con't.)

laminates reinforced by glass fibre mats, parallel rovings or such laminates in which two layers of glass fibres lie at a 90° angle to each other, is followed by a discussion of mechanical and physical properties as demanded by the building industry. A second article shall investigate the use of such laminates for the transfer of forces in the building industry.

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KUNSTSTOFFE-RUNDSCHAU

November-December, 1956

Abstracter: Leo Fischer

GRILON-NYLON 6, A POLYMER AS MATERIAL FOR PIPE MANUFACTURE—W. Steiner.

A full analysis of mechanical and chemical characteristics of Nylon 6 Polymer (a poly-caprolactum resin) in pipe and tubing. The article indicates that high molecular weight condation products have a great advantage production wise as well as in mechanical performance. As the molecular weight of polymer increases the flexural strength and modulus of elasticity increase, as well as resistance to hot water. A high moisture content of polymer before extrusion is advised to increase bursting strength. M Formulations used in testing do not give reliable results unless moisture content before extrusion and subsequent water absorption is taken into account. What is claimed to be a very reliable formula for estimating the maximum pressure tolerance of tubing is given. A polyamid of 500,000 molecular weight was used. Methods for heat distortion tests, chemical tests, water reaction tests etc. are given.

PRODUCTION AND CHARACTERISTICS OF PARALLEL GLASS ROVING MATS FOR GLASS FIBRE LAMINATES—W. Beyer.

An increase of modulus of elasticity of 365% is indicated by using parralel rovings sized with Epoxy binder when used in laminates. A thorough description of method and exact specifications are given as well as formulations and instructions for testing procedures. It is advised that fibres do not exceed 10 microns in D; as binder 85% Shell Epon resin 834, Epon 562-15% dissolved in 2½% acetone, activated with 9% diethylene triamin. This resin system is sprayed on fibres as the parallel rovings leave the winding drum and then the mat is oven cured. For maximum strength mats are laid up at 90° angles, uniform structure throughout. Thin layers of random mats on top and bottom may be used, as well as heavier matting in centre for proper distribution of stress resistance. Various types of construction, using parallel mats as described above and other mats are described in great detail.

TACRYL — A NEW AND COMPLETELY SYNTHETIC FIBRE FROM SWEDEN — Swedish Technological Institute—Ingeneer Synden.

An acrylonitrile fibre is described which is not dependent on the use of any existent patents. The basic difference between the usual method of producing these fibres (Orlon) and the technique developed by the Swedish firm Superphosphate Mfg. Co. is that the Swedish method uses a wet spinning process, a technique hitherto not practical. The basis of this achievement is the development of an aliphatic solvent for the acrylonitrile. This solvent enables them to wet spin in a highly efficient manner at a lower cost and produce a superior fibre. Comparitive test results are given with regular dry spun Orlon and Polyester fibres and Tacryl.

ISOTACTIC RESINS — Erich M. Bayer.

Dr. Bayer describes the work of Prof. Giulio Natta of "MONTECATINI" of Italy. Dr. Natta has developed a new series of Crystalline polymers which he calls "Isotactic." He has applied the Ziegler catalysation technique using metallic catalysts of an organic nature, to the polymerisation of various resins and has greatly increased the melting points (Polystyrene to m.p. 225° C) and improved tensile strengths and other qualities. His method uses a co-catalysation system with metallic catalysts such as $TiCl_4$ — $Al(C_2H_5)_3$, $TiCl_3$ — $Al(C_2H_5)_2$ and many others, with a specific for each resin. The theory is that the polymers thus formed have a spiral structure and Dr. Natta's full and complete structural formulae are presented and explained.

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DER PLASTVERARBEITER

November, 1956

Abstracter: Leo Fischer

WHY IS BERLIN USING MORE SYNTHETIC TROWELED FLOORING—Heinz Claus.

A type of troweled floor is being used extensively in Berlin, consisting of a polyvinyl acetate dispersion mixed with various fillers and pigments, and troweled by hand and scrapers to a smooth and highly polished surface. It is spread in several layers, each layer dried before application of the next one. It is advised to have a concrete or asphalt base to work on. Can be applied onto a wet floor; many patterns, colors and inlays have been made.

JOINING LIGHT METALS WITH SYNTHETIC RESIN ADHESIVES.

This article discusses principles of adhesion of metals to metals, using Araldite epoxy as example. Defines "adhesion" as the bonding mechanism dependent on molecular factors; "cohesion as the strength of the resin itself. In the case of resins adhesion is greater than cohesion in all cases.

MOLD FINISHING FOR PLASTIC INDUSTRY.

Complete discussion of method, technique and shop practice of finishing and lapping molds with diamond compounds.

TAPERED EJECTION PIN INSTALLATION IN INJECTION MOLDING MACHINES — Heinrich Spies.

The customary ejection mechanism in injection molding machines consists usually of an adjustable threaded ejector pin pushed out by ram in back of mold when machine opens. Variations in thrust of ejector ram are thus not allowed for as well as variations in pressure. A precise mechanical drawing is presented illustrating an improved tapered ejector pin, activated by springs. This takes up any variation in the thrust or pressure of the ram. The tension and length of spring is adjustable with a key, the whole unit being enclosed in a steel tube. This devise has been practicle in 1 oz. to 8 oz. machines. The chief value of this pin seems to be in molding very thin expendible cups of styrene or polyethylene. Since these resins have to be in a very liquid form, that is high heat, to obtain the low viscosity needed for thin wall molding, a vacuum is often created the ejection disc and ejection is often difficult. A groove is therefore cut in the ejector disc and is subjected to slight air pressure. Another groove contains a felt ring with parrafine oil and thus protects the molded piece from abrasion when ejected. Uninterrupted cycles of 10 pieces per minute without rejects is claimed by using this type of pin.

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GREAT BRITAIN

PLASTICS

October, 1956

Abstracter: Alfred Rexer

POLYESTER LAMINATING RESINS—Part 2. J. Brydson and C. W. Welch.

The concluding part of an investigation designed to bring about a closer understanding of the relation-

ship between the chemistry and properties of polyester laminating resins.

THE PROPERTIES AND TESTING OF PLASTICS MATERIALS—Part 8. A. E. Lever and J. Rhys.

This part discusses the testing of finished moldings. Tests covered are: impact strength, cross - breaking strength, crushing strength, electric strength, surface resistivity, plastic yield, resistance to heat, specific gravity, and water absorption.

VAPOR PRESSURE OF PLASTIC MATERIALS. Niels Jensen.

This article covers the procedure used to determine if certain high polymers have low enough vapor pressures to be used in vaccum systems with confidence. The sample was placed in an oven which in turn was in a container and the entire system then subjected to various temperatures and vacuum to determine experimental data. Materials evaluated were Teflon, polyethelene, saran, Mylar, Vinyl, Nylon cloth, Hycar and Butyl rubber. A table of data obtained giving the values for the materials investigated is included. The author feels these materials will find wide uses gaskets, dielectrics, low friction surfaces, and insulators.

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ITALY

POLIPLASTI

July, August, 1956

Abstracter: Alfred L. Alk

RECENT DEVELOPMENTS IN THE SECTOR OF PLASTIC MATERIALS IN THE U.S.A.—Malcolm W. Riley.

Review of developments during the past two years based on the last plastics show. There are three sections, Materials, New Technology, and Standards and New Applications. A brief paragraph is devoted to each item discussed under these three headings.

A COURSE IN THE APPLICATIONS OF POLYESTER RESIN — Sandro Rossi.

A noted Italian manufacturer ran a course during the past June in the applications of polyesters for technicians interested in these kinds of polymers. The course included practical demonstrations by trained personnel as well as theoretical discussions including cold forming, vacuum forming, lamination between rolls and in a press, and as a wood finish.

ISOTACTIC POLYMERS — Elvio Fachinelli.

Professor Natta of the Milan Polytechnic Institute has, by developing more specific Ziegler type catalysts, opened a new field in low pressure polymer formation. The new polymers, called "Isotactic" are obtained from various alpha-olefins. Professor Natta distinguished three fundamental types of polymer; (1) isotactic — substituent R groups lie in the same plane along the polymer chain; (2) sindiotactic — the substituent R groups alternate from one side of the chain to the other in a regular manner; (3) atactic — the substituent R groups have a random arrangement along the chain. The first group has had the most study. The characteristic spiral structure of the molecular chain confers certain properties to isotactic polymers quite different from the amorphous (atactic) polymers prepared at high pressures. The polymers are solids with a high degree of crystalinity even at low molecular weights (polypropylene at 2500 with the crystaline structure of a much larger molecule). An ionic method of polymerization is required to prepare the resins with proper chain configuration. A solid, stereospecific catalyst, such as a titanium halide, by which the monomer is absorbed, provides the key to this type of reaction. The isotactic polymers have considerably higher fusion temperatures than comparable atactic polymers. Isotactic polypropylene has a resistance to tensile rupture approaching that of steel. Licenses have been isuued by Montecatini to most of the major plastic manufacturers in the United States.

EPOXY RESINS—Arrigo Sandri.

Although epoxy resins have been kown since 1930, it is only recently that they have become of industrial interest. They have high reactivity; exceptional adhesion to metals, glass and other materials; resistance to chemical attack; minor shrinkage during hardening; dimensional stability on aging; strength; and controlable degreeg of flexibility. Major uses presently are as surface coatings, adhesives and cements. Epoxy resins are prepared with epichlorohydrin and any of a variety of chemicals having hydroxyl groups in their molecules, the most important of which is presently bis-phenol A. Condensation products with bis-phenol A are characterised by (1) ether linkages in the molecule making it less liable to saponification, (2) a great distance between the reactive portions of the molecule lending flexibility for cross linking reactions, (3) polar nature of the molecule which explains its great adhesion. In the field of adhesives, the epoxies are excellent and are held back only by their relatively high cost. This can be overcome by formulating adhesives for specific end uses. By changing conditions of preparation, resins which cure at ambient temperatures or with one or two hours of bake may be prepared. These may be considered as two stage resins which reach their most inactive state upon further reaction above 200°C, under which conditions the reactive groups in the molecule all react. In the field of coatings, epoxies are solving some of the problems of fragility, lack of chemical resistance and lack of adhesion encountered in present plastic finishes. Characteristics of co-polymers are discussed and typical uses noted. Epoxy resins are having increasing use in encapsulation where they approach optimum requirements: low viscosity, long pot life, low gelling temperature, short curing time, minor shrinkage, good adhesion, low water absorption, good electrical properties, etc. For this purpose a low weight polymer is used which is cured with either an addition agent or by means of a catalyst. In laminates, the use of epoxies has increased tremendously because of their stability, adhesion to fibre reinforcements and strength. Although their cost is still high, use is expected to continue to grow. A list of Italian applications of epoxy resins and their manufacturers is included.

THE USE OF REINFORCED PLASTIC MATERIALS IN THE AUTOMOBILE INDUSTRY—Giorgio Anglesio.

The article describes types of auto bodies and components produced in the U.S., names of manufacturers, and methods used in production. Production in several European countries is similarly analyzed. Problems of expanding production to commercial proportions are mentioned and are compared to some of the directions in which further development is being undertaken. Public transportation is the field in which the greatest use is being made of reinforced plastics because short runs are involved and because physical properties of the completed product are advantageous. Other products in which physical properties are particularly helpful are battery containers and gasoline tanks. In the latter case, maintenance cost is reduced by elimination of high temperature soldering.

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SWEDEN

SWEDISH PLASTIC ASSOCIATION TECHNICAL BULLETIN

Volume XI, Nr. 12, March, 1956

Abstracter: Walter Werber

THE DEVELOPMENT OF UNPLASTICIZED PVC APPLICATIONS IN CALENDERING, EXTRUSION AND INJECTION MOLDING — by M. van Kemmel, Solvic SA, Brussels, Belgium.

The author traces the history of rigid PVC from its origins to its present state. Beginning with reduced amounts of plasticizers in

(Please turn to Page 59)

SECTION NEWS

Edited by

Charles P. O'Donnell

Monsanto Chemical Co.
Springfield, Massachusetts

Western New England

Injection Molding Developments

C. P. O'Donnell

Mr. Gordon B. Thayer, Plastics Technical Service Specialist of Dow Chemical Co., was the featured speaker at the Western New England Section's January 9 dinner meeting. The talk, given in the Bradley Field Terrace Dining Room, concerned "Recent Injection Molding Developments" and was held under the technical chairmanship of Mr. Richard Plichta, Fuller Brush Co.

Mr. Thayer introduced his theme with the statement:

"Theories and hypotheses in conjunction with laboratory and molding plant experience, have combined to uncover a few key points or fundamentals with respect to high injection speeds, melt extraction heaters, mold rigidity, hot runner molds, polyethylene, thin wall moldings, automatic operation and other topics of feverish interest to most of the people in the injection molding industry."

He went on to say that the heavy responsibility plastics engineers assumed in making engineering and equipment recommendations would be somewhat mitigated if fundamental reasons could be added to the observations and experiences reported. The speaker explained that his talk was an endeavor to discuss key points in an attempt to determine a basis for orderly appraisal and continued development. Many of the points he would discuss were unanswered, and possibly others in the field could supply these answers, all of which might serve to establish the necessary fundamental reasoning which was now so sparse.

Melt viscosity and heat transfer characteristics, the Dow representative explained, can be shown to verify the good results reported with melt extraction heaters. These heaters are helpful in eliminating air from the melted plastic, which in turn is an aid in minimizing oxygen degradation. Extremely rapid melting of thin layers of plastic can reduce thermal degradation of thermoplastics and can provide a uniform temperature in the mass of plastic which is forced into the mold.

Some of the fundamental properties of polymers, such as melt viscosity and crystallization induction time, which have not received a great deal of attention in molding technology, appear to provide corroboration to some of the hypotheses which recent experiences in molding refinements indicate can be formulated.

Melt viscosities in relation to injection pressures for various thermoplastics, including polystyrene, high-heat polystyrene, acrylo-nitrile copolymers, and polyethylene, show some reasons why higher injection pressures make the polymers more fluid as readily as higher temperatures can, with less danger of thermal degradation.

Melt viscosities in relation to injection speeds show the advantage of high injection speed in making the plastics more fluid. Melt viscosities in relation to temperatures show why the mold should be filled rapidly, and is another positive indicator of the advantage of increasing injection speeds. Crystallization induction time for polyethylene is very short, and the mold must be filled quickly to avoid filling after crystallization has begun. A low mold temperature can be an advantage in obtaining short cycles for polyethylene because the crystallization time is shorter at low temperatures. Injection speed should be measured by the velocity of flow plastic and by mold fill time for reasons of correlation with the polymer properties.

Mr. Thayer remarked that with more and more being expected of plastics, more attention to every critical factor was needed. This is particularly true in eliminating oxygen degradation in the new polymers — developed in answer to the need to expand business operations. In avoiding oxygen degradation, a uniformly low plastic stock temperature is desirable; this uniformity would permit lower molding temperatures than are now prevalent, and thereby shortening cycles. To avoid heat degradation it is advisable to heat the coldest material, rather than increase heat at the heater wall, which would bring the high temperature areas of the plastic closer to degradation.

The guest then discussed Melt Extraction Heater Polyliners in connection with this search for answers to the above problems. Inserted into the heating cylinder, the heated polyliner allows passage of melted plastic from its inside core, through small holes, to the outside of its shell. By extracting melted material from the surface of the melt the liner permits substitution of unmelted sub-surface material, to be in turn melted.

Mr. Thayer deduced several desirable results from the use of the polyliner. Only plastic to be used immediately is melted, thereby obtaining the desired short melt period. The liner by-passes the problem of low thermal conductivity of plastics and is able to maintain a more even stock temperature. Although the stock in the center of the mass is close to melt point, it still is in granular form. This permits exhaustion of air as the stock is gradually compressed, thereby greatly limiting oxygen degradation. The Dow engineers also felt that use of the polyliner greatly reduced pressure loss at the extruding end of the cylinder. A brief discussion on shear rate and evidence supporting the belief that increased shear rate decreases melt viscosity, concluded the talk. In relation to this area, there are indications that the newer thermoplastics need increased pressures.

The Dow visitor used several slides to clarify the technical figures of his findings. They demonstrated the effect of graduated temperatures on melt viscosity; shear and pressures for both general purpose and high heat styrene; the design of the Melt Extraction Heater Polyliner; shear rate in relation to pressure increases; and other slides on melt viscosity temperatures and relative to crystallization induction time.

The subsequent question and answer period was quite animated and developed further areas of interest to the S.P.E. membership. Mr. Thayer commented on his group's development of a "Coplastometer" for testing melt viscosities. He offered literature on the meter's development and application to all interested S.P.E. members writing in.

The meeting ended after a note of appreciation for Mr. Thayer's appearance from the Section President, Mr. Lew Gustafson (Pro-phy-lac-tic Brush Co.)

The Detroit Section's Mother-Son combination — Mary Denny and her son, Richard (Dick) Denny.

Detroit

Unique 'Family Team' In Plastics

The Detroit Section holds the unique distinction of being able to boast of one of the most unusual "family teams" in the entire plastics industry.

Throughout the plastic realm, many cases are brought to mind of sons following in their father's foot-steps by carrying on his efforts towards the realization of "Better Plastics Through Engineering," but rarely does one find a Mother and Son combination pursuing the same plastic endeavor. Consequently the members of the Detroit Section can point with pride to Mary Denny and her son, Richard "Dick" Denny both of whom are actively associated with the plastic industry through Whitlock Associates at 21655 Coolidge Highway in Oak Park, Michigan.

Mary is a graduate of high school and business college and took night classes in plastics to further her knowledge in her chosen field. Her business career began as a stenographer and switchboard operator in the Detroit office of the Monsanto Chemical Company and she rose to Sales Correspondent and Office Manager during her twenty year tenure. She resigned her position in 1949 to assume an active role as a partner in the formation of C. H. Whitlock and Associates. Mrs. Denny has been active in the SPE since its inception in 1941 and has for many years capably filled the office of Recording Secretary for the Detroit Section. She will be called upon this coming year to handle with Carl Whitlock, the General Chairman, the myriad of details involved in the successful planning of the National SPE Conference for 1958, to be held in Detroit next January.

Dick Denny enlisted in the Marine Corps in 1943 and spent three years in active duty overseas, being discharged as a Sergeant. Following his return, he entered Alma College and graduated in 1951 and then took post-graduate work at Wayne State University.

Dick is married and with Hugh Whitlock handles the sales for their company in Michigan, Ohio and Indiana. Dick and Hugh team up as Co-Chairmen of the House Committee for the Detroit Section as well.

Because of this, it will be conceded that the Detroit Section is composed of many closely knit relationships—both friendly and family!!

Upper Midwest

Electroformed Cavities

F. W. Brown

The Upper Midwest Section held its January 21 meeting at Worwa's Cafe. Paul Becker opened the meeting with a brief report on the January technical conference. Nineteen Upper Midwest members chartered a Braniff plane for the trip.

Our evening speaker was Mr. W. J. B. Stokes of the Electromold Corporation. His topic was entitled "Electroformed Cavities for Plastic Molds." Until recent years, widespread use of the electroforming process was prevented by several factors: stress in the electroformed deposits, inability to deposit metal in deep recesses, and the inability to plate thick shells. In 1951 the London and Scandinavian Metallurgical Company started a research program which several years ago culminated in electroformed molds called "Nicoform." Cavities produced by this process have a "working" layer of hard nickel and a backing of copper. Mold making by electroforming has opened up many new possibilities. Almost any material can be used to form the master because no stress is applied to the master.

Electroformed molds are characterized by perfectly matched curved parting lines, intricate surface design, sidewall detail and undercuts, efficient cavity spacing, sharp raised cavity detail, and accuracy. Mr. Stokes then cited the economics of repairing and replacing damaged cavities by the electroforming process. Electroform repairs are for surfaces and are accomplished without stress or distortion of the part. Molds should be chrome plated for thermo-setting resins but need not be for thermoplastic. Mr. Stokes gave an interesting and informative account of electroforming and concluded his remarks by exhibiting a number of molds.

Central Indiana

Design Problems Of Acrylics

C. R. Smith

Despite the threat of hazardous driving conditions, thirty guests and members of the Central Indiana Section turned out on January 29th, to hear Mr. Mort Blumenfield of Rohm & Haas Company, discuss design problems as they pertain to Acrylic Materials.

Mr. Blumenfield prefaced his talk with a basic explanation of the refractive and reflective qualities of acrylic plastics. A series of colored slides illustrating the paths of light rays introduced at various angles to different acrylic parts vividly demonstrated the critical nature of light transmission in this material as well as a means of controlling it through good design.

While admittedly each part presents its own design problems, Mr. Blumenfield did set forth some fundamental principles to be observed in dealing with decorative acrylic applications. In his opinion the surest way to a successful design is through the use of careful model work.

This meeting also served to introduce the following new Section Officers: President, Mr. Harold Riley, Jr., Riley Heating Equipment Co.; Vice President, Stephen Ransburg, R.C.A.-Victor; Secretary, Mr. Walter Ellsworth, Industrial Mfg. Corp. and Treasurer, Mr. John Remley, R.B.M. Division.

Detroit Leaders Prepare For 14th ANTEC

The Executive Committee has been selected for the next Technical Conference which is to be held in Detroit in January 1958.

This committee has held several organizational meetings with the various local chairmen to formulate plans to feature technical papers with an International flavor. Plastic engineers from England, France and Germany will be invited to discuss the use of new plastic processes and materials together with their practical applications in their countries.

The members of the 1958 Technical Conference Executive Committee reading from left to right are: Fred Schwab, Treasurer; John Slater, Co-Chairman; Carl Whitlock, General Chairman; Jay Kuhn, Co-Chairman; Iver Freeman, Secretary.

Connecticut

Fabrication Of Fluorocarbons

David Mersey

The Connecticut Section's January meeting took place at Bridgeport on the eleventh of January. Mr. J. W. Clarke of the Joclin Manufacturing Company, North Haven, Conn., specialists in the fabrication of the fluorocarbons, presented the program.

Teflon with its unique thermal, mechanical, electrical, and processing properties is a newcomer to the field of plastics materials. It was discovered in 1938 in connection with research being done on refrigeration gases. Although classified as a thermoplastic, in compression applications it is handled as a powdered metal, i.e., its processing techniques are based on its ability to be cold formed and then sintered at high temperatures. Teflon does not lend itself to injection molding.

This compound comes in a granular powder for molding (types 1 and 5) and extrusion (type 6); and in dispersion (type 30) for coatings and impregnation.

We feel we cannot improve on the book, so we take a page from duPont . . . "Teflon, tetrafluoroethylene resin, is one of the most remarkable high polymers created by chemical synthesis in that it has a combination of useful chemical and physical properties which cannot be found in any other single material of construction, natural or manmade. Teflon is outstanding in its extreme inertness to chemical attack, unusually high thermal stability, low dielectric loss and high dielectric strength, unique nonadhesion and low coefficient of friction, and in its retention of properties over an extraordinary wide range of temperatures."

Mr. Clarke described the various methods of fabrication, namely, compression, extrusion, spray coating, impregnation or dip-coating. Briefly, and this is very brief, compression involves two steps. In the first, the compound is cold-formed or compressed. This is followed by a baking or sintering process at between 680 and 740°F. Teflon has a compression ratio of 4:1. Processing in this respect is similar to powder metallurgy. Extrusion is usually done with a ram type extruder. Here the compound is converted to a paste by the use of white oil or other extrusion aid. Type 100X has a melt viscosity low enough to permit extrusion in standard screw type machines. Coatings are applied over a primer, and although Teflon is very inert it can be had in a complete color range from clear to black. It may also be impregnated into other materials, such as, asbestos, felt, metals, etc.

To facilitate his talk, Mr. Clarke showed some excellent slides, and a large variety of parts fabricated by his company.

Kansas City

Trends In Injection Molding Equipment

K. A. Kaufmann

The Kansas City Section held its regular monthly meeting January 8 at Milleman's Restaurant on the Country Club Plaza. The featured speaker for the evening was Mr. Tom Bishop, Sales Manager, Plastics Machinery Division of HPM, on the subject of "Trends in Injection Molding Equipment."

Mr. Bishop explained how the development of new materials and the use of polyethylene in housewares and large industrial moldings has had considerable effect on the design of molding equipment. His talk was well illustrated through the use of many slides depicting very interesting and unique molded parts and molding machinery.

Special heating chambers for 16,000 pounds injection pressure have been developed for polyethylene molders. These in turn allow larger bushings and plungers and thus increase shot capacity for a given machine. Similarly, 30,000 pound chambers have been developed for Cycolac and acrylics for easier molding. This causes derating of machine capacity. It is generally true that such changes in shot size for a given machine are proportional to the changes in unit pressure.

Additional stroke and daylight provisions are trends specifically resulting from polyethylene houseware items such as wastepaper baskets, garbage cans, buckets, and the like. This means that it is not necessary to purchase a machine of higher shot capacity than needed simply to obtain space for deep draw products.

Injection speeds have increased 50-100% in the past several years, but the demand for even greater speeds continues to be heard. Mr. Bishop pointed out that such injection speed is costly and dependent upon machine size. For instance: 200 and 400 oz. machines shoot 7,000 cubic inches per minute, while 4 and 6 oz. machines shoot 400-500 cubic inches per minute. He felt that higher than normal speeds should be offered as optional equipment rather than increase basic machine price for all applications.

Special heating cylinders for specific materials are beginning to be developed such as the duPont polyliner and the Maccaferi chamber. If this trend continues, rather than general purpose cylinders, considerable expense must be borne by the injection molder. Automatic cycle features and low pressure mold closing were stated to be very desirable for automatic molding and the importance of positive ejection molds for this use was stressed.

The work of the SPI on uniform rating standards for injection equipment and interchangeable mold standards was reviewed.

Newark

Maintenance Of Molding Machines

Robert A. White

The first meeting in the new year, 1957, was an indication of the growth of the S.P.E. and of the interest of the membership of the Newark Chapter in its activities and responsibilities.

The January 9th meeting was a joint session, the Newark Section being hosts to the New York Section, with a total attendance of 175 members and guests.

After a brief discussion of business matters, the group was addressed by Irving Rubin, the new president of the New York Section. Mr. Rubin spoke briefly of the bright future in view for the plastics industry.

Announcements were made on the pending trip to the Annual S.P.E. Convention. Advance flight reservations for group travel of Newark Section members were sold out.

The panel discussion on the Maintenance of the Hydraulic Molding Machine was moderated by Mr. W. W. Gryce, Executive Engineer with Louis Marx & Co., Inc. Mr. Gryce advised that perhaps the title of the discussion should be "The Care and Feeding of the Molding Machine."

The first speaker, Mr. John G. Thompson, chief engineer of the Injection Molding Machine Division of Lombard Governor Corp., spoke on Machine Maintenance. Mr. Thompson's analogy to Aircraft Maintenance encompassed planning inspections, daily operating inspections, appraisal of information, and maintenance of records—these providing a basis for prediction of work to be done. Preventative Maintenance was defined as the prevention of breakdown; enabling one to choose the time to perform maintenance as experience indicates from evaluation of maintenance records.

Mr. F. R. Cinco, Electrical Engineer of the Reed Prentice Corp., stressed the importance of proper maintenance of electrical equipment. The effectiveness of such a program being reflected in the number or frequency of shutdown for emergency repairs. An important phase of electrical component maintenance is the identification and evaluation of critical items, and providing for replacement of such components.

The outstanding deterrents to proper functioning and long life of electrical equipment are dirt, dust, chemicals, improper lubrication and vibration. Mr. Cinco indicated that consideration is being given to the issuance of an electrical maintenance data sheet by Reed Prentice, as a supplement to those provided by the manufacturer of the basic components.

Mr. G. C. Bonnell, assistant service manager of Vickers, Inc., in discussing the Maintenance of the Hydraulic System, made a perfect analogy to the human circulatory system. Pressure, temperature, oil condition and noise all tell a story, as does the blood pressure and condition, body temperature and noise of the heart or pump. Brief mention was made of the service school conducted by Vickers to assist in training hydraulic maintenance technicians. An invitation was extended to all present to investigate the program and advantages offered. Superior maintenance requires selected men, trained to analyze and trouble shoot, checking circuit prints before dismantling equipment.

Hydraulic fluid, as the life blood of the system, was well presented by Mr. Robert O. Sharpe, Senior Engineering Representative for Socony Mobil Oil Co. The essential characteristics of the fluid were discussed in detail. Effect and function of viscosity, oxidation stability, film strength, rust prevention and demulsability were all discussed. Flame resistant materials were also touched upon; the additional costs of such materials being considered as insurance premiums for fire prevention.

Isocyanate Symposium . . .

This is just a part of the crowd at regional Isocyanate Symposium conducted by the Upper Midwest Section. It was held in Minneapolis, Minn., on October 23.

Southern

Acrylic Resins In Lighting Uses

John W. McCauley, III

At a joint meeting of 52 I.E.S. and 26 S.P.E. members, three speakers presented the major advantages and disadvantages of the three major plastics used in the lighting industry. The acrylic resins were discussed by Paul Landers, Sales Engineer for the Rohm and Haas Co.; polystyrene by W. E. Brown, Mgr. Testing Section of Dow Chemical Co., and vinyls by D. A. Hills of Luminous Ceiling, Inc.

Mr. Landers pointed out the light stability, clarity and high rate of light transmission of the acrylic resins. He also observed that the main reason acrylics weren't used universally in lighting was that in some applications, primarily indoors, other materials were able to do a satisfactory job at a lower initial cost. The rigidity and ease of forming of acrylic sheets however, did account for considerable use of this material for indoor modular units and specialty lighting fixture.

Mr. Brown, in discussing polystyrene, agreed in principle with Mr. Lander's remarks regarding indoor and outdoor comparisons of the two materials. He pointed out that the main disadvantage of polystyrene in lighting, that of color stability, was rapidly being eliminated by the styrene producers. He observed that newer formulations of light stable polystyrene can serve in ultra violet light for five years of normal exposures without noticeable degradation of color. On the advantage side, besides low initial cost, Mr. Brown pointed out that styrene offers similiar design properties and ease of forming to the acrylics.

Mr. Hills' discussion concerned primarily the completely lighted ceiling but he also pointed out that foot square modules of formed vinyl sheet are rapidly becoming a factor in the lighting field. Vinyl strips or modules offer a self extinguishing, high intensity—low brightness ceiling that incurs no penalty on fire insurance rates when installed below sprinkler system. Ease of installation and cleaning as well as low initial cost were other advantages. He observed as did Mr. Brown, that vinyl producers were rapidly eliminating the disadvantage of color stability.

At the December meeting of the Southern Section, the 1957 officers were announced as follows: Thomas H. Hart, President; Herbert F. Loring, Vice President; W. B. Erb, Secretary; John W. McCauley, Treasurer.

Southern California

Progress Report on Tool Plastics

R. K. Griffith

The Southern California Sections of the S.P.E. and S.P.I. met jointly at Scully's Restaurant on January 10. Past S.P.E. President, William J. Dewar, presented the new officers: D. A. Hamilton, president; R. K. Griffith, vice-president; J. G. Fuller, Jr., secretary; and Tom Schaub, treasurer. The new section directors are Leo Costanza, Tom Schaub, and Charles Zimmerman.

W. Brandt Goldsworthy, S.P.I. Chapter President, introduced J. Allen Carmien, Chairman of the S.P.I. Pacific Coast Plastics Exposition and National Conference. Mr. Carmien outlined the activities of his committees and their progress. The Exposition and Conference are scheduled for March 18 to 21. In the 20-year history of S.P.I., this is the first time these events have been held in the West. Space in the Exposition was sold out during the first offering. Arrangements are being made to accommodate a long waiting list. Every indication points to the most successful Exposition and Conference to date.

Mr. Norry Hastings of Hastings Plastics presented "A Progress Report on Tool Plastics." Looking back to the 1946 S.P.I. West Coast Symposium, Mr. Hastings noted that tool plastics were well established on the Coast at that time. Pioneers in this field included Albert Nobell, Nobell Resins, and C. L. Wurdeman, Rezolin, who successfully developed and applied phenolic casting resins. From Southern California, tool plastics spread across the U. S. and abroad.

With numerous advantages over metal, wood and plaster, tool plastics now find countless applications in the aircraft, automotive, appliance, and plastics industries. Phenolics have partially yielded to polyesters and those in turn to epoxies. A relatively stable price structure for all three resins has not retarded their rapid growth. Thermal limitations of existing resins present a challenge to the industry.

A variety of plastic tools loaned by the Douglas Aircraft Company and North American Aviation, Inc., were discussed. Questions from the audience stressed interest in the use of plastic tools for polyester and injection molding.

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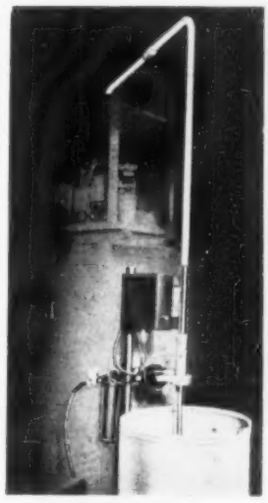

Hopper Loader

"Plastics in Building"

New York Sets April 3 For SPE Regional Conference

SPE New York Section will hold its second technical conference on April 3, at the Hotel Statler in New York City. Papers will be presented which should be of interest to all **plastics engineers, contractors, architects, decorators,** and **designers.**

Simultaneous materials sessions will be held throughout the morning, beginning at 9:00 A.M. Topics, and manufacturers supplying speakers, have been scheduled tentatively as follows:

Thermoplastics—Decorative Plastics

Acrylics—Henry Peterson, E. I. du Pont de Nemours & Co.
Polyethylene—Fred Sutro, Spencer Chemical Co.
Styrenes—Harold Cooper, Koppers Co., Inc.
Vinyls—J. F. Nichols, Chicopee Mfg. Co.

Thermosets—Structural Plastics

Phenolics—Douglas Roe, Bakelite Co.
Polyesters—C. W. Proudfit, Celanese Corp. of America.
Epoxies—E. Dorman and D. Senseman, Ciba Co.
Melamines—W. F. Drees, American Cyanamid Co.
Foams—E. M. Bailey, National Aniline.
Fiberglas—Richard Adams, Owens Corning.

The afternoon session on applications has been established as follows:

Design—Jane Mitarachi, Editor of Industrial Design Magazine.
Plastics in Lighting—J. B. Orr, Sheffield Plastics.
Furniture & Interior Decoration—Adi Fitzner, Fitzner Assoc.
Piping & Plumbing Fixtures—M. Martin, Bassons Industries.
Plastics Building Components—Lou Contini, Monsanto Chemical.
Plastics and Building Codes—Frederick Rarig, Secretary, Rohm & Haas Co.
Summary of New Applications—Clayton Meyers, Bakelite Co.
Buckminster Fuller will speak on Buildings of the Future at the dinner.

Tariff and other undesirable statistics.—

	Members	Non-Members
Registrations only	$ 5.00	$ 9.00
Registration & lunch	$ 8.00	$12.00
Registration & dinner	$11.00	$15.00
The "works"	$15.00	$19.00

Checks, payable to SPE, and sent to Herbert W. Weber, Rotuba Extruders, Inc., 437-88th Street, Brooklyn, N. Y., will be accepted up to March 29. Those willing to chance a waiting line may pay at the door—we expect an attendance of over 600.

Society of Plastics Engineers, Inc.
% Herbert W. Weber
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New Gating for Acrylics . . .

(Continued from Page 20)

Summary

The benefits to be gained by the two types of gating discussed are better appearance, more uniformity from cavity to cavity, reduced welds and sinks as a result of a more intimate contact with mold surfaces without excessive pressures; uppermost is the apparent improvement in such physical properties as craze resistance and dimensional stability.

It is impossible to recommend a universal standard gate or tab size that would suit all types of molded parts. With the data listed herein on a large variety of molds and shapes, it should be possible to select combinations to suit the mold being designed. The following basic recommendations are widely used in molding acrylics:

1. Sprue Bushing—11/32" dia., "O" end
2. Nozzle —9/32" dia.
3. Runner —5/16" F.R.—Below 10" 3/8" F.R.—Above 10" in length
4. Tab —Minimum of 0.375" wide x 0.625" long x 7/8ths of the cross section deep.

   It is important that the gate be located in the center of the length of the tab for best dispersion of material into the cavity.
5. Land length should not exceed 0.075".
6. It has been found that an increase of the tab area is more beneficial than an increase in gate size. The restriction must be maintained.

Much of the information reported here is the result of intense curiosity and searching on the part of our customers. Without their complete cooperation the work never could have been started or completed. Included among these are die casting people from whom much can be learned about flow.

Reference is also made to the excellent paper by Bostwick and Joslin of Bakelite Co., on restricted gating of vinyls, which appeared in the October 1953 issue of Modern Plastics.

book reviews

TECHNICAL SEMINAR ON SYNTHETIC LATEX POLYMERS. Published 1956 by Goodyear Tire and Rubber Co., 44 pages, paper bound.

This collection of papers by key Goodyear technical personnel presents helpful information on synthetic latices, particularly of the butadiene-styrene type, to prospective users in the paint, paper, textile and other fields. Scope of the discussion includes theory of emulsion polymerization, evaluation procedures, latex manufacture and latex applications, all presented in a simple, practical non-theoretical (and non-commercial) manner. Papers by D'Ianni and Smith are especially well done in this respect.

More and more chemical concerns are utilizing the technical seminar approach in promoting raw materials. The Goodyear effort appears to be a worthy representative of its class, and will no doubt be of interest to many SPE members in the paint, paper and textile industries.

D. E. Cordier

Baltimore-Washington

New Plastics Materials and Uses Are Forecast

Lewis C. Wallace

Mr. R. L. Van Boskirk, editorial consultant to **Modern Plastics** and editor of the "Plastiscope," presented an interesting paper on "What's New in Plastics."

As an indication of the tremendous growth of the importance of our industry, Van Boskirk revealed that it was only twelve years ago that he and Pete Rector (then of WPB) put together and published the first comprehensive statistical report of the plastics industry.

The "hottest" comer is duPont's "Delrin" from formaldehyde. While this material won't be available commercially for "several years," according to the manufacturer, its extremely low water absorption, heat resistance, flexibility and potentially low price make it one of the more exciting developments of 1956.

Boron plastics are interesting, but information is all but absent from the literature. Since the Armed Forces are interested in boron plastics as fuels, and plastics users want them inert, the chemists have their work cut out.

Methyl Methacrylate costs keep coming down. The growth of this material will tend to be at the expense of glass reinforced polyesters.

Rigid PVC plastisols, laminated vinyl sheet, irradiation polymerization, development of stereo-specific (isotactic) polymers, rigid and flexible foams, and medium density polyethylene are the fields tending toward most rapid growth. Improvements in handling techniques for PVC may well make this the first billion pound per year resin, instead of polyethylene.

New officers for the year are: President, Clare Milton; Vice President, Dr. Al Lightbody; Treasurer, Barney Franklin and Secretary, Miss Nancy Rucker.

A rousing ovation was given Irv Wolock, the outgoing President.

Al Lightbody announced that the section's first Annual Technical Forum is receiving enthusiastic support. An adequate number of high quality papers have been received to assure a technologically significant meeting. Host for the meeting is the Naval Ordnance Laboratory, White Oak, Maryland. The all-day meeting will start at 9:00 A.M. on Wednesday, March 13.

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I have spent several months studying the Constitution and By-Laws of the SPE. Along with this study has been a study of the changes which have been made and the changes which have been proposed since 1951. A study of the proposals to change and of the changes made reveals what I consider to be a glaring fallacy in the thinking of this day and age. The thinking error to which I refer is the failure to consider that the "status quo" is one of the alternatives. The usual philosophy seems to be: "We have to make SOME change." However, to this we could reply; "Why? Why, do we have to change ANYTHING?"

My observation is that most of our difficulties in any program stems from one of three things. (1) Too hasty consideration, (2) acting on incomplete information, or (3) catering to someone's prejudice or preconceived idea. I do not counsel delay for the sake of delay, in fact, I believe just the opposite. When the time comes for making a decision, make that decision on the basis of the most complete information available or obtainable. Delaying a decision while waiting on some information that may or may not be provided, is only to delay the final day of reckoning. In any case, the first decision that has to be made is that we MUST decide either pro or con in a particular matter.

A decision to "do nothing," i.e. continue doing exactly as we have been doing, can be just as important as any other decision we can make. The thoughts expressed here are occasioned by the fact that Congress is in session. Several of the State Legislatures are also in session. I am frightened by the multitude of bills tossed into the hopper. Obviously, many of them are directed toward gain for some particular pressure group. I feel that many times our public officials say, in effect, "We are going to change the law. Do you want it changed to read ——— or ———." Actually, their first question should be whether we want to have the law changed.

In case you have become confused about the theme of this article, let me try to express the theme by a simple illustration. When driving your auto-

mobile along a main highway, do you stop at every intersection and decide whether to make a right turn or a left turn? Of course not!! You continue on the well traveled and well defined highway to your destination. Your destination was decided in advance and you are not swayed or influenced by the fact that there are countless opportunities to make decisions along the way. It is only when you arrive at a MAJOR intersection that you feel called upon to check your maps to make sure that you are continuing on the right road. It makes little difference just what route you choose to travel, provided that you have previously decided your destination. Let us, as a Society, set long range goals (Such as the establishment of a PLASTICS INSTITUTE) and then proceed directly toward that goal without spending much time at local intersections.

Wayne I. Pribble

PLASTICS AROUND THE WORLD

(Cont'd. from page 50)

Sweden . . . (con't.)

Europe to achieve rigidity to modified types in the USA the word unplasticized was coined in the USA and replaced the former term "rigid." Reason for this was the fact that only totally unplasticized PVC affords the spec. Datas required for tubes, pipes, and sheets by the chemical industry. Classification of unplasticized PVC can now be grouped into:

1. extrusion of tubes for industrial and food applications
2. calendering of sheeting for decorative and packaging purposes.
3. extrusion of films for packaging
4. injection molding for industrial application (fittings, etc.)

Volume XI, Nr. 20, May, 1956

FABRICATION TECHNIQUES FOR UNPLASTICIZED PVC SHEET — by W. E. Martin, BX Plastics Ltd. London.

Purpose of this paper is to give the user a complete instruction manual on the fabrication method for above material. It begins with a discussion of the chem. and phys. properties and continues in great detail into the fabrication methods, such as cutting, vacuum forming and finishing e.g. printing, cleaning. A very valuable treatise for the manufacturer who has problems with rigid Vinyl sheets or anyone who intends to work with this material.

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Nuclear Research . . .

(Continued from Page 28)

by 1 inch thick, and is cemented to a tapered acrylic light pipe. Again, the photomultiplier tube is positioned so that it looks through the acrylic light pipe at the edge of the plastic fluor.

When accelerated particles traveling near the speed of light in vacuum or in air enter a material of appreciably greater density, they find themselves traveling actually faster than the speed of light in that particular medium. Under these conditions they produce a visible glow known as a Cerenkov radiation. This phenomenon is utilized in a number of ways. Figure 8 shows a piece of apparatus using a square of acrylic plastic to detect and count high-velocity particles by means of Cerenkov radiations. Here again, photomultiplier tubes look at the edges of the detecting material through acrylic light pipes.

Another device for the detection and analysis of high-energy particle reactions is a cloud chamber. One form of this device contains an atmosphere of hydrogen gas saturated with methyl alcohol vapor at a pressure of somewhat more than 500 pounds per square inch. This poses the problem of how to construct windows through which to illuminate the chamber for taking pictures. Glass is unsatisfactory because of high mechanical and thermal shocks involved. A satisfactory solution was arrived at by the use of a polyester casting. Figure 9 shows two stages of the manufacture of these windows. The material is cast in the form of a ring, which is machined to size and then cut into four 90° segments, polished, and grooved for gaskets.

The newest development for the high-speed analysis of high-energy particle reactions is the bubble chamber, in which the speeding particle leaves a trail, or track, of vapor bubbles in a liquid. The tracks are made to curve by strong magnetic fields and are photographed for precise measurement and analysis. Such a device is now under construction, and will use liquid hydrogen for the active medium. To create a strong magnetic field, there will be two coils, each with 190 turns of 1.3-inch-square copper conductor with a 1-inch diameter cooling-water hole in the center. The conductor will be wrapped with two layers of 0.002-inch polyester film tape; the turns will be separated by a 0.020-inch-thick continuous strip of polyester and fiberglass mat and asbestos laminate; between the layers, or "pancakes," will be two thicknesses of this material; and the coil will be insulated from the surrounding steel by two layers of 0.062-inch polyester and fiberglass cloth laminate.

Many other examples could be cited involving vinyls, silicones, fluorocarbons, nylons, and so on and on. This paper can illustrate only a selected few, but these serve to illustrate how much the continual flow of new plastics materials and ideas have helped to further scientific research.

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Molding Thick Laminates . . .

(Continued from Page 38)

Molding Studies

As mentioned earlier, a number of 7/16" thick panels were matched metal die molded in an attempt to establish some correlation between exotherm data and internal delamination. It was repeatedly established that conditions of too short molding cycle or too high peak exotherm, individually or in combination, produced internal delamination. In this series of more than 100 individual moldings of 12" x 12" x 7/16" panels that were inspected for internal delamination, it was found that the molding cycle should equal or exceed twice the time measured for the exotherm to reach its peak and that the peak exotherm should not exceed 320°F, in order that void-free panels might be molded.

Conclusions

In conclusion, it is our experience that an important cause of internal delamination in thick laminates is the high peak exotherm temperature obtained in the interior of the panels. This exotherm can be lowered by decreasing the catalyst concentration, lowering the platen temperature, increasing the filler content, and the judicious use of chain transfer agents or chain stoppers all of which must be compromised with the economical need for shortest possible molding cycles. The use of catalysts with slower decomposition rates appears to be another possibility for obtaining lower exotherms, but has not been fully investigated at this time.

Acknowledgment

The author wishes to express his gratitude to the Hooker Electrochemical Company for permission to present this paper, to Mr. Paul Robitschek, Manager of Plastics Research, for his helpful comments and suggestions, and to Mr. D. W. Kloda of the Plastics Laboratory for the experimental work.

Electroformed Molds . . .

(Continued from Page 35)

Getting hold of these pieces to withdraw them properly from the cavity is frequently a problem. Whenever possible, the pieces should be pulled from the cavity. Knock-out pins operating from the bottom of such cavities, if there is the slightest reluctance of the piece to release, will tend to expand the molded piece and wedge it tighter into the cavity. It should be mentioned that some remarkable successes have been had with such bottom knock-outs. A danger that always exists with bottom knock-outs in deep narrow cavities is sidewall scoring.

Another design possibility through electroforming, unique to electroforming, and deserving special consideration, is what we term the "pseudo-undercut." This is where the undercut is formed by a twisting, turning or bending in the design of the molded piece. The individual off-shoots of these cavities are generally well drafted. Of course, the resiliency of the molding material must be sufficient to permit the withdrawal of the molded piece by the necessary flexing. Again in this type of cavity, withdrawal is best effected by pulling rather than pushing. One problem in such cavities is the venting of the branches. This can often be done by electroforming a tiny blind vent at the end of each branch. These vents frequently do not require connection to the outer air.

Electroforming also opens the field to molding of plastic parts that have true undercuts. This is one of the most exciting contributions of electroforming to the molding of plastics. It opens whole new fields of decorative and engineering design. True undercuts .006 inches deep on sidewalls having only two degrees draft have been molded by millions. Undercut depth possibilities are dependent upon the material being molded, the diameter of the molded piece, the wall thickness of the piece, the nature of the undercut, and the shape of the sidewalls where the undercuts occur. It should be frankly admitted, however, that we do not always know just how it is possible for these undercut pieces to get out of the cavities without damage. Somehow they do, though, and we are formulating general rules which seem to be applicable.

We realize it is difficult to step away from the conventional mold constructions. However, if we are to receive full advantage of the possibilities of this new mold making process, we must adjust our designs to permit these cavities to work to their best advantage. The fact that it was difficult to make high cavities for shallow pieces by electroforming was once considered a handicap, but when we adapted our mold design to the resulting low cavity parts, we found that we could have a more economical mold construction, and also a better performing mold. We know it is very difficult to disregard a practice of many years and to design a cavity with deliberate undercuts. We have seen many molded pieces made in split cavities with the resulting unsightly parting line, where these same pieces could have been molded upright in a one piece electroformed cavity, and probably at substantially less cost.

It is impossible to make any general rule regarding the use of electroform cavities. A part may be such that hobbing, casting, or machining are perfectly logical methods for producing cavities. But an insignificant change in the part can make these methods impractical from a cost or time standpoint, and electroforming can be an easy and economical solution.

This new art requires new thinking on the part of mold designers, and designers of plastic parts. It demands imagination and originality and, for those who have these qualities it brings an opportunity to pioneer.

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Moisture in Nylon . . .

(Continued from Page 25)

molded." Consequently, the molder should first establish whether or not conditioning is necessary. This can be accomplished very simply by comparing the actual performance of a few "as molded" test parts with the same parts that have been conditioned to 2.5% water by boiling in aqueous potassium acetate. The aqueous potassium acetate method is suggested here because as pointed out earlier, it gives good control over the amount of water absorbed and we believe this to be important for a test comparing the performance of "as molded" and conditioned parts.

Once the need for conditioning of parts intended for service in air is established, the simplest and most practical production method is again the use of boiling water. Since the part is intended for service in an atmosphere averaging 50% relative humidity, the boiling in water should stop when the parts have reached an average water content of 3 to 4 per cent. This will insure an average of 2.5 per cent as any excess will evaporate rapidly from the surface in service.

We are continuing to study the other methods of steam conditioning for these offer attractive possibilities and low unit cost on large production runs.

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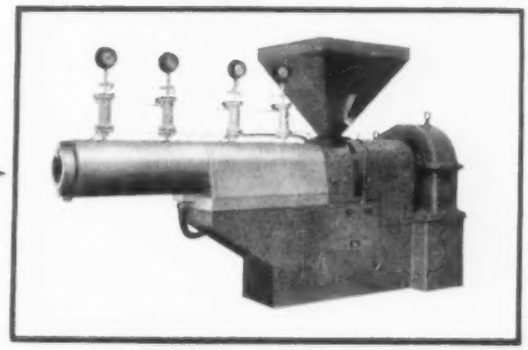

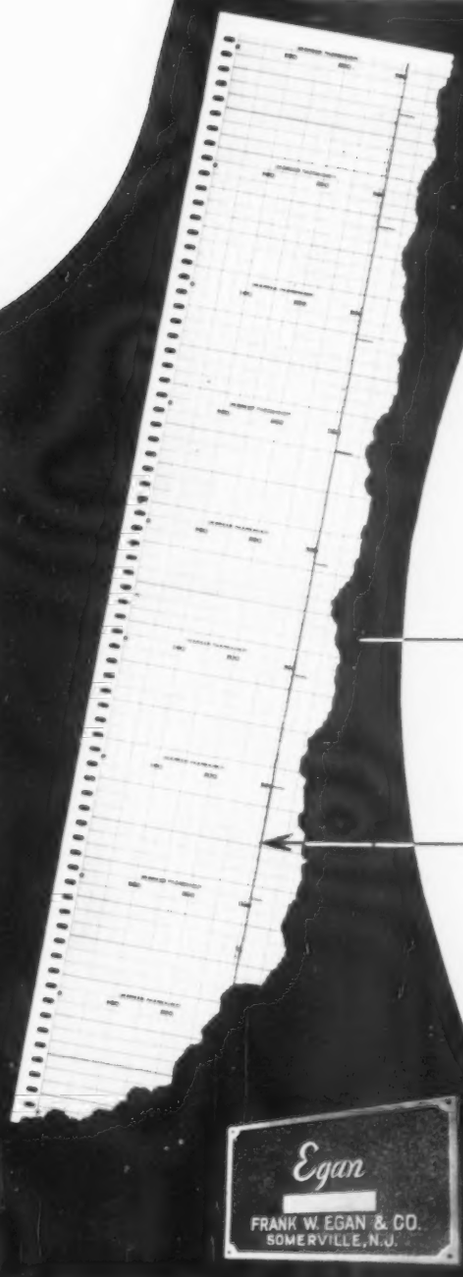

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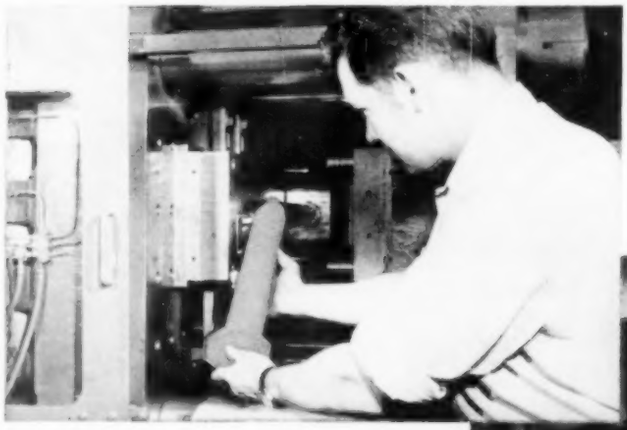

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